INSTITUTE OF TERRESTRIAL ECOLOGY

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GUIDELINES FOR LAND USE AND LAND COVER DESCRIPTION AND CLASSIFICATION

Draft Final Report

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B K Wyatt, C Billington, K de Bie, J de Leeuw, N Greatorex Davies, R Luxmoore

ITC

Institute of Terrestrial Ecology

WORLD CONSERVATION MONITORING CENTRE

Monks Wood
Abbots Ripton
Huntingdon
Cambridgeshire
PE17 2LS

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CONTENTS

LIST OF ANNEXES

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1. PREFACE

This Report describes the results of a Corporate Contract between the United Nations Environment Programme (UNEP) and the Institute of Terrestrial Ecology (ITE), with additional financial support from the Food and Agriculture Organisation of the United Nations (FAO). The overall purpose of the work was to improve the consistency of the nomenclature used to record land use and land cover, particularly in the context of global applications. The study, the first stage of a planned longer-term programme of work, aimed to develop the prototype for a global reference framework for recording data on land cover and land use, as a basis for inter-conversion between specialist systems. The work was undertaken between 1994 and 1996 by staff of the ITE, in association with colleagues from the Institute for Aerospace Survey and Earth Sciences (ITC) and from the World Conservation Monitoring Centre (WCMC), under the guidance of a Steering Group, made up of experts from the commissioning agencies and from other international bodies with an interest in the study objectives and applications. Membership of the Steering Group is listed at Annex 1.

2. INTRODUCTION

As the world population increases and peoples' economic aspirations grow, it becomes increasingly important to reconcile demands for more productive land uses with the need to protect the environment, biodiversity, and global climate systems. In the search to achieve this goal, information on land use and land cover, in the form of maps or statistics, has become a vital tool for research, planning, policy development, appraisal and implementation, in the fields of environment, agriculture, forestry and land resource management at local, national, regional and international levels. There is a particular need to monitor and model interactions between land use and environmental change in all these areas of application. Technological developments, including remote sensing and computer-based geographical information systems make it increasingly possible to map and monitor land use and land cover over wide areas and to deliver the basic information, but a number of technical and organisational factors restrict the uses to which this information can be put.

Notable among these is the lack of consistency in the way in which land use and land cover are recorded. At the present time, there is no agreement world-wide on precisely what constitutes land use or land cover, or on how to define them. As a result, many classification systems and innumerable map legends exist, and maps and statistics from different countries, and in many cases even from the same country, are incompatible with each other. The consequences of these differences in have been graphically demonstrated, *inter alia*, by (Wyatt *et al.* 1994) and Defries and Townshend 1994. In Figure 1, we see striking differences between estimates of the global extent of important land cover categories from four independent surveys. These differences are in part due to differences in the land survey methods employed; however, differences in nomenclature, and in the precise way in which class boundaries are defined, may have equally far-reaching effects on quantitative results. Canopy cover is frequently specified as a key variable in determining the class to which forest land is assigned. Figure 2 demonstrates how changing canopy cover threshold condition influences the extent of land mapped as forest in Senegal.

Figure 1 Area estimates of 11 cover types from different global datasets

Figure 2 Dependence of mapped forest extent in Senegal on canopy cover threshold

It is self-evident that there are enormous benefits to be gained if all the groups currently working on the collection, management and utilisation of information on land use and land cover could collaborate and build on common principles. A common approach would maximise the deployment of limited funds and would help to ensure that the resulting information can be exploited as widely as possible. Conversely, separate approaches, which may result in incompatible data and statistics, as far as possible should be discouraged.

2.1. Background to this report

The recommendations presented in this Report are the result of a joint initiative between the Food and Agriculture Organisation of the United Nations (FAO) and the United Nations Environment Programme (UNEP), aimed at developing just such a common approach to the description and classification of land use and land cover. The work came about as a result of a number of related activities undertaken between 1988 and 1994. Some of these activities are described in the following paragraphs.

2.1.1. FAO Initiatives

Within FAO, the Soil Resources, Management and Conservation Service has responsibility for land classification and land use planning. From about 1988, this group began to develop more objective methods for describing and classifying land use (internal documents, and Remmerzwaal 1989, Adamec 1992). In 1990, a land use information group was established, consisting of FAO, the Wageningen Agricultural University (WAU), the Wynand Staring Centre (SC-DLO) and the International Soil Reference and Information Centre (ISRIC), Wageningen, and the International Institute for Aerospace Survey and Earth Sciences (ITC), in Enschede, and FAO commissioned a study by ITC, WAU and SC-DLO to develop a format for the description of land use and a prototype land use database (Stomph and Fresco, 1991). Following completion by WAU, in 1992, of an initial study on Land Use Classification (Mücher, 1992), FAO then commissioned a study by ITC and WAU on classification of land use, which resulted in a proposal for a global land use classification (Mucher, Stomph, and Fresco 1993). From 1992 onwards the development of the database and the underlying concepts, were taken further by ITC and FAO and were tested in Botswana, Mozambique, and Swaziland in 1993. The resulting system is described in a Users' Reference Manual (de Bie *et al.*, 1996) and the database forms an important input to the work described in the present Report.

2.1.2. IGBP

Meanwhile, a number of similar activities were in train, driven by the needs of the global climate change research community and co-ordinated through the International Geosphere Biosphere Programme (IGBP). Most notable of these was an initiative, under the auspices of IGBP-DIS (Data and Information Systems), to compile a map of the world's land cover (DISCover, IGBP-DIS, 1996) at a resolution of 1km, using multi-temporal satellite remote sensing. Contacts were developed with this group to facilitate exchange of ideas and joint concept development, particularly in relation to land cover nomenclature and this Report builds extensively on these discussions.

2.1.3. Relevant Regional and National Programmes

Simultaneously, the AFRICOVER project was under development by various African governments, in partnership with FAO's Environment Information and Management Service (SDDR). The purpose of AFRICOVER is to prepare basic geographic information to support the information requirements for information on land cover of actual and future programmes on natural resources in African countries. In 1995, the AFRICOVER project established a Technical Working Group on Legend and Classification, responsible for developing the methodology for definition and classification of land cover units for the project, and for drawing up specifications for the database to be used. In the spring of 1996, results from the work described in the present Report formed an input into the design of the AFRICOVER classification, and the two projects have since become closely integrated (see Section 6).

In 1992, the UK Government responded to the need for greater harmonisation of national data and maps describing land use and land cover by commissioning ITE to undertake a study aimed at developing systematic procedures aimed at both qualitative and quantitative inter-comparisons between a number of classifications in use nationally and in Europe. An important output from this study, (Wyatt *et al.* 1994), was a computer-based system which allows equivalent categories in any two classifications to be identified by reference to a 'Baseline' or 'Reference' nomenclature. The UK study formed a useful prototype for the present Report.

2.1.4. UNEP

At this time, UNEP, through its Harmonisation of Environmental Measurement Programme and through more broadly-based programmes in collaboration with FAO, was working with other international agencies, including the World Conservation Monitoring Centre (WCMC) and the IGBP Global Change in Terrestrial Ecosystems (GCTE) programme to promote greater consistency in approaches to the classification of land and vegetation (UNEP-HEM, 1993). In 1993, UNEP provided funds for a survey of existing land use and land cover classification methods (Young 1993). When this was discussed at a joint UNEP/FAO expert consultation in Geneva in November 1993, it became clear that the goal of a single global classification was unrealistic. Instead it was agreed to initiate a dialogue with groups and institutions who were active in the field, in order to jointly develop a common approach, and at the same time to initiate a project to further develop an improved method for systematically recording land use and land cover, and for inter-relating existing nomenclatures. The first of these activities was developed through a network of individuals and institutions, using air- and Email. The second is the subject of this Report.

2.2. Objectives of the Study

The overall objective of this study is to develop an approach which will support the production of uniform statistics at global level and at the same time provide a detailed, quantitative, and eventually georeferenced basis for land use and cover modelling and analysis at field level. This implies a methodology which extends from top to bottom in the vertical sense (i.e. it should be applicable at any scale) and which is comprehensive in the horizontal sense (i.e. any identified land cover or land use anywhere in the world can be readily accommodated).

This broad objective has been addressed at a number of levels, each of which was planned to generate different outputs.

2.2.1. Generic data model

At the most generic level, it was necessary to develop a conceptual framework which encompassed the above objectives of scale-independence and general applicability. The intended output from this activity was a generalised data model, which could be exploited in a wide variety of database applications for the management of land information.

2.2.2. Glossaries

A second objective was to develop the glossaries of pre-defined terms needed to describe land types or classes in terms of their functional attributes. These attributes include land use properties, such as management operations, inputs, outputs and a systematic and the land cover characteristics required by the above data model. These glossaries were intended to be more than structured lists of terms and were designed to include unambiguous definitions and, where appropriate, quantitative specifications of boundary conditions.

2.2.3. Inter-comparison of existing classifications

Methods were required to allow any existing classification to be equated, or correlated with any other. This demanded, firstly, the ability to record land classes in terms of the above data structure, using terms and categories from the glossaries, and, secondly, the development of a set of rules and software to facilitate the description, entry and storage of land use or cover types and the process of translation between them.

2.2.4. Reference classifications

Although the concept of a single standard for land classification is not likely to be realisable, guidelines for the development of future systems and for the avoidance of past inconsistencies in classification would be generally welcomed. One of the objectives of this study was therefore to develop classifications of land use and land cover which would serve the function of a reference system that would be adaptable for specific applications in a wide range of applications and in diverse geographical settings.

2.2.5. Database design

It was intended that the data model (Objective 1) could be exploited in the design of land use and land cover databases to store raw field data resulting from ground surveys, or the output from interpretation of remotely sensed data

2.3. Methodological approach

2.3.1. Harmonisation *vs* Standardisation

One solution to the problems arising from inconsistencies in classification and nomenclature might be the universal adoption of a single standard basis for land use and land cover classification. However, even if this were desirable, it could not be achieved in the short or medium term, because of the heavy financial and intellectual investment in established methods and databases by existing users. Furthermore, it is probable that there will always be a need for specialised classifications for particular purposes.
A more acceptable solution would take the form of a system that allowed individual countries and institutions to continue to use existing data systems and nomenclatures,

and which, at the same time, permitted the separate datasets to be combined much more easily than at present, preferably with minimal effort on behalf of the data originators and without significant information loss. This approach, based on *a postiori* inter-comparison of information collected or organised using different extant classifications, was applied successfully to British and European land use and land cover classifications in the earlier UK study (Wyatt *et al.*, 1994) and similar methods have been used in the present study.

2.3.2. The rôle of a reference system for inter-comparison of land classes

Given unique and unambiguous definitions of what comprises a particular land use or land cover class, it is perfectly possible to compare directly two or more classes and to estimate class overlap, at least quantitatively. Problems arise a) when definitions are imprecise, ambiguous or absent (this is a disconcertingly frequent occurrence) and b) when many different classification schemes are involved, and the number of pair-wise comparisons becomes excessive. Little can be achieved by anyone, other than the designers of the systems concerned, to deal with the first problem.

To solve the second difficulty - the number and complexity of comparisons necessary to reconcile land information across a large number of different sources - a common reference system is needed, with which to represent any *a priori* classification. Correspondence between terms in the classifications of interest may then be inferred from the explicit record of how each relates to the reference system. This would require translation into the reference system just once, and would obviate the need for pair-wise comparisons between every classification of interest.

If it is to be effective, such a reference system must be logically consistent and able to accommodate a diversity of different perceptions of the land surface. Because it must be widely applicable, the reference system would be well-suited to form the basis for a generally-acceptable **classification,** which could be promoted as a future standard. For the same reason, it would also provide a sound basis as a data model for use in the databases needed to manage information on land use, land cover and other land attributes.

The present Report describes the development and structure of such a reference system for land information and explores two of these areas of application, *viz.*:

i) inter-comparison of existing (*'a priori'*) classifications;

ii) development of standard reference classifications of land use and land cover.

2.3.3. Parametric approach to the description of land

Classification has been defined (Sokal, 1974) as the ordering or arrangement of objects into groups or sets on the basis of their relationships. Conventional approaches to classification, especially when these involve hierarchical subdivision, can lead to logical problems in class assignments. For example, if a land cover class 'Forest' is initially sub-divided by the phenology of its constituent trees into 'Deciduous' and 'Evergreen' subclasses, the dichotomy between 'Broad-leaved' and 'Needle-leaved' forest can be introduced into this structure only by repetition (Figure 3).

Figure 3 Multiple classification dimensions within a dichotomous hierarchy

FOREST
- Deciduous Forest
  - Broad-leaved Deciduous Forest
  - Needle-leaved Deciduous Forest
- Evergreen Forest
  - Broad-leaved Evergreen Forest
  - Needle-leaved Evergreen Forest

This rapidly becomes unmanageable, as additional facets are introduced: for example, further subdivision in terms of bioclimate (e.g. 'Cold Deciduous' *vs* 'Wet Deciduous') or species composition.

An alternative, and much more flexible approach, is to represent individual classes within land classification systems in terms of their functional attributes - a finite number of parameters, chosen to record, for example, aspects of land use, the nature of the surface cover or other environmental conditions. A data model of this form can then be used to represent categories in an *a priori* classification system, to describe a physical land unit or to record information about a land parcel in a database.

Using this model, the land class (or land unit, or data record) is represented **parametrically** by a logical association of keywords or values which describe its distinguishing attributes. Figure 4 illustrates how this approach is used in the ITC Land Use database (de Bie *et al.*, 1996) to characterise land used for the cultivation of root crops.

Figure 4 Parametric description of land used for the cultivation of root crops

ROOT CROPS

Species/Service:	Root/tuber plants
Product/Benefit:	Plant produce, tubers
Land Use Operations	
Crop Production:	Temporary (arable) cropping
Livestock Production:	None
Extraction/Collection/Grazing:	None
Settlement/Industry/Commerce:	None
Recreation/Tourism:	None

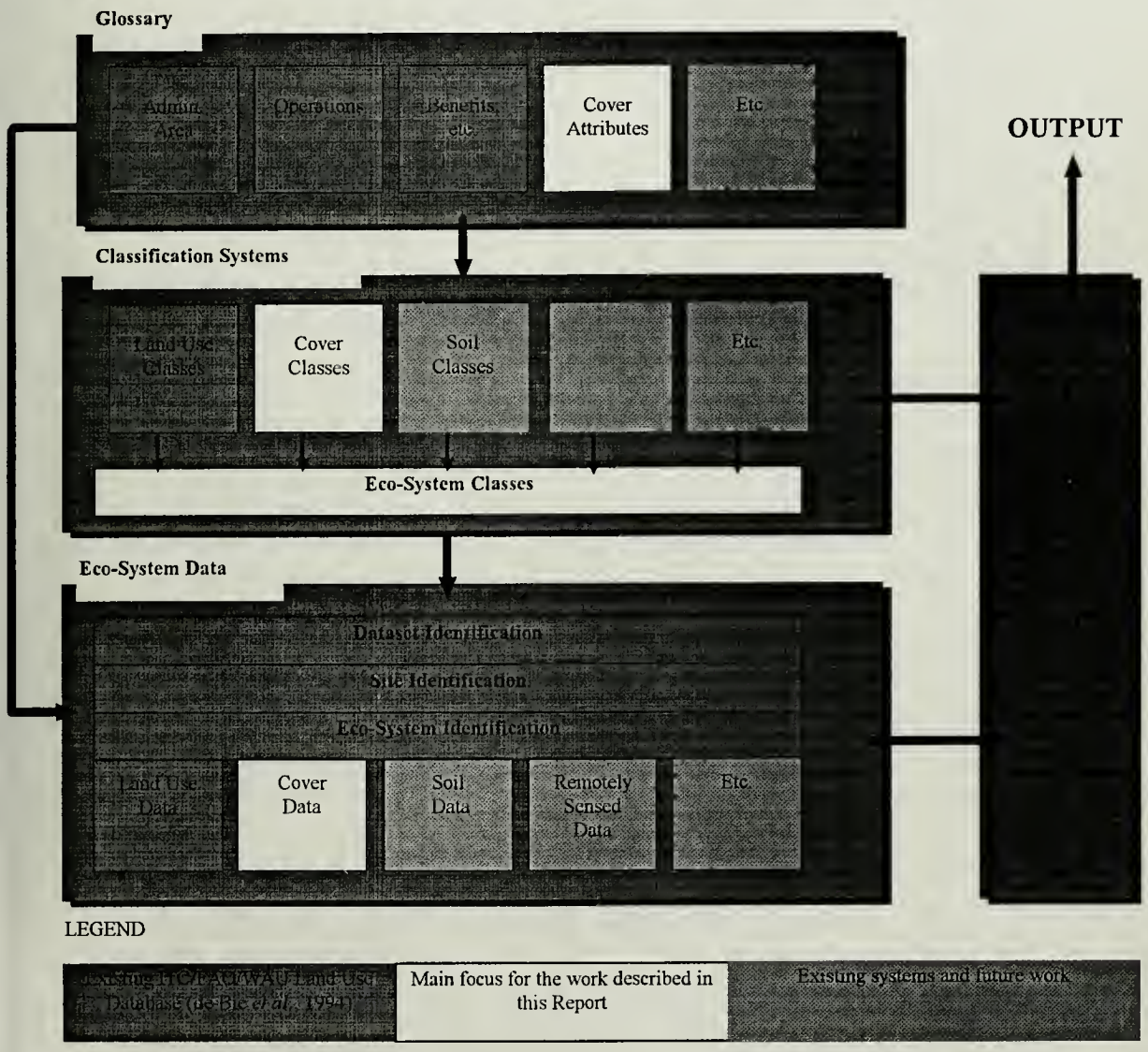
(Species/Service = Root/tuber plants) AND (Product/Benefit = Plant produce, tubers) AND (Crop Production = Temporary(arable) cropping) AND (Livestock Production = None) AND (Extraction/Collection/Grazing = None) AND (Settlement/Industry/Commerce = None) AND (Recreation/Tourism = None)

Inter-comparison of land classes recorded in this way is then achieved by intersection of logical expressions such as the example given in Figure 4.

2.3.4. A modular data model for land information

Land classifications commonly mix concepts of land cover, use and other environmental land attributes such as soil type or climatic zone. This often leads to ambiguity and confusion. In the present study, we have designed a modular data model, in which we establish a clear distinction between attributes of land usage, land cover and other contextual properties that may be necessary to describe physical land units. The distinction between land use and land cover is explained more fully in the following section of the Report. The additional contextual attributes needed include soil type, climate, topography, hydrology and other facets of the environment in which the land unit occurs.

Figure 5 Modular model for land information



The structure of the data model is shown schematically in Figure 5. The existing ITC Land Use Database provides the framework for recording land **use**, and the work described in this Report focuses principally on land **cover**. For many of the remaining modules needed, terminologies exist which are widely recognised as authoritative. For example, the FAO soil classification (Food and Agriculture Organisation, 1990) provides an internationally-recognised framework for the description of the world's soil types. It is envisaged that the complete implementation of this data model would build on such established practice, rather than attempt to develop new concepts and notations *ab initio*.

2.4. Key definitions and concepts

Differences in present methods of land classification are central to this study. any of these differences can be ascribed to the absence of commonly-agreed concepts and terminologies or to the failure of users to conform to those standards which do exist. It therefore follows that, if the aims of the study are to be realised, then the principles adopted must be clearly articulated and unambiguously defined.

2.4.1. Classification

We have already defined **classification** as *'the ordering or arrangement of objects into groups or sets on the basis of their relationships'* (Sokal, 1974). Classification necessarily involves definition of class boundaries. These should be clear, precise, where possible quantitative, and based upon objective criteria, so that the outcome would be the same whoever the user.

The result of the classification activity is a **classification system**. A classification system comprises a logical framework, holding the names of the classes, the criteria used to distinguish them and the relationships between classes. Classification systems may or may not be hierarchical, but hierarchies which descend from a small number of generalised categories at the higher level to a large number of more detailed categories at the lower levels are commonly used, especially where the classification is intended to be applied at a range of scales.

According to Sokal, the term 'classification' is also commonly misused for what is better termed **identification**: this is the process of assigning additional new unidentified objects to the correct class. The development of a classification system for plant communities such as the British National Vegetation Classification (Rodwell, 1991) is an example of classification. The assignment of a plant community name to a vegetation record according to British National Vegetation Classification is called identification.

2.4.2. Legends

Legends are often confused with classifications, but there are crucial differences. Strictly, a **legend** is the application of a classification for a particular purpose, for example, for thematic mapping. Whereas a classification should recognise the entire universe of sets that make up its subject matter, a legend may contain only a proportion, or sub-set, of the classes in the classification from which it is derived. Some classes may be omitted; others may be combined into composite categories. As with the classification from which it is derived, the items in a legend should be defined; for example, a map legend should contain as much helpful information as possible, in order to assist the user to understand and visualise the reality which is being depicted.

In reality, the practice often falls well short of this ideal. Often, legends are simply a list of the features (e.g. plant species) which are common in a particular mapped unit. There may then be no parent classification, and the items in the legend may have no relationship in terms of type or scale of detail (for example Forest [multi-species cover], Vineyard [single species cover], and Horticulture [use class], in the same legend). It is often difficult or impossible to compare maps of this type in a quantitatively meaningful way.

2.4.3. Land

Although there is no internationally agreed definition of "Land", there is a widely-accepted convention (e.g. Food and Agriculture Organisation, 1994) that the term refers not just to the solid surface of the Earth, but to all the natural resources that form the basis for land use, including climate, water resources (above and below the surface), vegetation and fauna. We have adopted this definition in this study. Included in the definition are water bodies, both inland and marine

2.4.4. Land use and land cover

Central to the subject matter of all land information systems are the concepts of **land use** and **land cover**. The distinction between them is fundamental, but, in practice, this distinction is all too often ignored, leading to confusion and ambiguity in many existing and previous classifications. Two examples serve to illustrate the difference between land cover and land use. The land **cover** 'Forest' is distinguished by characteristics of its physical components, such as vertical vegetation structure, vegetation height and density. Conversely, the land **use** 'Forest, is characterized by the purpose(s) to which the land is put, for example, 'Rubber tapping', 'Conservation of biodiversity', 'Recreation', 'Timber production', 'Shifting cultivation', etc. Similarly, the land **cover** 'Grassland' is distinguished by the presence, or dominance of herbaceous vegetation ('grass'), while the land **use** might be 'Hay production', 'Grazing', 'Recreation' or 'Not used'.

From these examples, it follows that land **cover** may be determined by direct observation, whereas information on land **use** requires a statement of purpose from the person who controls or carries out the land use. Remotely sensed data, e.g. from aerial photographs or satellite images, can be used to map land cover, for example, by identifying multi-spectral signatures characteristic of land cover types. Land use, in turn, may be correlated with actual land cover, so that land cover may be employed as a means of inferring land use.

2.4.4.1.*Land use* is a description of **function**, the purpose for which the land is being used. Definitions which have been proposed include "*the management of land to meet human needs*", and "*human activities which are directly related to the land*" (Young, 1994). It is helpful to regard a land use as a series of activities undertaken to produce one or more goods or services. The concept has proved to be a robust one, and has withstood the test of time. Building on these ideas, the Land Use Database developed by ITC, FAO and WAU (de Bie et al., 1996), adopted the following definition of land use:

> *"A series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources."*

If we adopt this definition, land use types can be described in terms of a series of

activities and their associated inputs and outputs. For example, the agricultural land use "Wheat field" is defined by the series of activities undertaken on specific dates to produce a crop of wheat (the output), together with the inputs required to carry out each activity. A given land use may take place on one, or more than one piece of land, and several land uses may occur on the same piece of land. Definition of a land use in this way provides very precise distinctions between land uses, and may even be used as the basis for analysis of economic and environmental impacts.

2.4.4.2.*Land cover* is the observed physical cover, as seen on the ground or through remote sensing at a given location and time. This includes the soil surface, vegetation (natural or planted) and human constructions (buildings, etc.) which cover the earth's surface. Water, ice, bare rock or sand, and salt flats or similar un-vegetated surfaces also comprise land cover.

Whereas there is an established conceptual model for describing land use, to our knowledge, no comparable schema exist for describing land cover in a similarly structured way. For this reason, this was the principal objective of the study described in this Report.

3. PRINCIPLES UNDERLYING THE DEFINITION AND CLASSIFICATION OF LAND UNITS

In Section 2.3, we demonstrated the need for a systematic approach to the description and classification of land use and land cover which clearly distinguishes these two concepts. Many extant classifications, maps and information systems lack this intellectual rigour. It is common to mix concepts of land cover and land use; indeed, these facets are often inextricably linked with other environmental attributes, such as soil type, climate, bio-geographical zone, altitude or topography. In other words, classification systems which purport to address land use or land cover, often, in reality, describe more general land systems, or **ecosystems**, of which land use and land cover are specific aspects.

Although it is a legitimate objective to classify such composite land ecosystems, it is important that they are not be confused with pure land use or land cover classes in the process. To avoid this confusion, we propose a data model which distinguishes the different categories of environmental classifiers required (see Figure 5). Within each module of the model, there are three distinct domains: the classification level, the domain of terminology (the glossaries) and the database itself.

3.1. Land classifiers

Classification of land must be based on well defined diagnostic criteria. We refer to these criteria as **classifiers**. One or more classifiers, in combination, define a **land class**, when each classifier represents a distinguishing characteristic or **attribute.**

We define a **land attribute** as:

> "*A property of land, that can be measured or estimated, and that is used to distinguish land units from each other.* (Fresco *et al.*, 1994)"

In our modular design, the sub-systems (land use, land cover, environment....) are structurally and functionally different. Different classifiers are therefore needed to describe each sub-system. Land **use** classifiers include those which define purpose, or the operations carried out to achieve the stated objectives. Land **cover** classifiers define the characteristics (composition, size, extent, density, etc.) of the objects, such as vegetation, water, rocks, soil or built features, that contribute to the cover. These concepts are explored separately for land use and land cover in following sections.

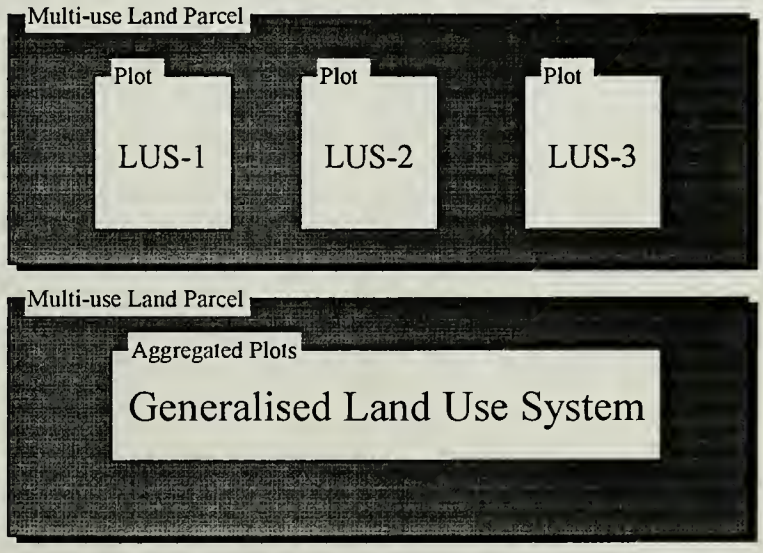
3.2. Issues of Space and Time

In both land use and land cover a time element is involved. Land use may change over time, either cyclically (e.g. crop rotational systems) or irreversibly (e.g. deforestation for agricultural land use). Land cover may change seasonally (e.g. fields may be bare or crop-covered, depending on time of year).

In the case of land cover, especially, spatial scale becomes an important issue, since the scale of heterogeneity of land cover may be smaller than the resolving power of the survey method used. For example, in many examples where trees and grass are intermixed, individual patches of the separate components may be indistinguishable from current space-based remote sensing data. Differences in the vertical dimension, particularly in forest canopies, may also be significant.

We strongly adocate the principle that both land use and land cover should be independent of time and space - in other words, that they should represent land use (or land cover) at a point in time and at a specific location. The design of the **classifiers** should always respect this principle.

Figure 9 **a) Grouping of Land Use System Descriptions.**
b) Generalised Land Use System Description at Smaller Scale.



However, there will be occasions where it is useful or necessary to specify land **classes** which describe large spatial units (e.g. an administrative area) or extensive periods of time (e.g. a complete year). The same principle applies in both cases, though the spatial problem is easier to visualise than the temporal one. There are two possibilities:

3.2.1. Grouping of land descriptions

Descriptions can be grouped, e.g. by map unit, holding, region, time period, etc., by references to units identified at finer spatial or temporal scales. For example, if land use information is collected for several plots in a parcel, the land use descriptions of all the individual plots may then be grouped by parcel (Figure 9a).

3.2.2. Generalised description of land systems

Alternatively, the hierarchical structure of the glossaries (see Section 3.3 below) makes it possible to generate a single generalised description of a number of different plot-specific land systems, in terms of their common properties. That description is then in general terms and is valid for all locations or time periods involved (aggregated plots; Figure 9b).

3.3. Glossaries

In database applications, land classifiers are assigned qualitative or quantitative values. Examples of this might be:

> *Cover: Dominant, Height > 2m, Species/Service: Plants by use, cereals, Product/Benefit: Grain (cereals).*

It is clearly necessary to control and to define the terminology used to define these values in order to ensure consistent description and storage of land information. This is achieved through the use of a glossary of standard nomenclature. The Land Use Database developed by ITC (de Bie *et al.*, 1996), incorporates an extensive glossary, covering terminology needed to define land use classifiers. In the present study, we have extended the structure and content of this glossary to include the terms needed to describe land cover. The glossary has also been expanded to cover other environmental classifiers, including climate, geology, geomorphology, soil and land history.

Although these glossaries now contain a large number of terms, they are still far from complete, nor is it possible for one group of users to cover every single possible requirement for land terminology. The intention is that the present glossaries should provide a basic structure on which to build and expand in response to new applications and requirements. In other words, the glossaries are tools for controlling nomenclature that are flexible in the sense that they may be adapted according to the needs of the individual user.

In updating the glossaries, items may be added, edited, moved, documented and deleted. When adding items to the glossary, certain 'rules' must be taken into account. Items at one level of a glossary tree must be mutually exclusive, i.e. they must not overlap. For example, the item "plant produce" and "seeds" must not be at the same level. The second rule is that the contents of different glossary trees must be mutually independent.

3.4. Land Classification Systems

Definitions of land classes may be arranged to form a **land classification system.** This is formally defined as:

"*A structured collection of land class definitions.*"

Most land classification systems are hierarchically structured, and all should be based on two rules:

- At each level the defined land classes must be mutually exclusive.
- Classes at a lower level must be a further specification of a class at a higher level.

The second feature states that lower level classes are logical sub-divisions, which implies that classifiers used at one particular level are always valid for classes at a lower level. For example, if a classifier of a high level class states that a product is 'vegetative', the product of underlying classes must be 'vegetative' too, or a further specification of this, e.g. tubers, leaves, etc. It cannot change into an animal product or an immaterial/intangible benefit.

3.5. *A priori* versus *A posteriori* Classification

Land use classification can be *a priori* or *a posteriori.*

In ***a-priori*** classification, land use classes are prepared **before** the actual collection of data. Consequently, the classifiers are not based on collected land use information. This approach is generally used in circumstances where it is required to accommodate information within an existing framework. The main advantage of *a-priori* systems is that classes can be made to conform to the standards of well-known national or international land classification systems.

A-posteriori systems are based on classifiers defined after analysis of the collected data. The advantage of this method is that classifiers can be defined that meet the study objectives. If several study objectives are formulated, several *a-posteriori* classification systems may be prepared. Since the different classes are generated by manipulating the same set of classifiers, data can be transformed between classifications at will.

3.6. Inter-comparison of Classification Systems

There have been many attempts to develop a universal land classification; the first one known to the authors was published in 1949 (IGU), and the last in 1994 (UNEP/FAO). The present study focuses on the standardization of land **classifiers**, rather than on the development of a single standard **classification**. This provides the means of translating between *a priori* land classification systems. Each classification is described in terms of a common set of classifiers (of land use, land cover and environment) and correspondence between classification systems is established by looking for matches between the classifiers assigned to the different *a priori* classifications.

This descriptive exercise generated a considerable database containing descriptions of current land classifications in terms of a standard set of classifiers. From this database, it was possible to identify commonly-used classes and concepts and, from these, to develop an *a posteriori* classification, suitable for use as a future reference. We

undertook this task separately for land use and for land cover.

4. THE LAND USE - LAND COVER DATABASE

The central theme of this project was the design of a general-purpose database for land information. The focus was on:

i) the development of a consistent set of classifiers and associated glossaries to permit the systematic description of a range of land attributes, including land use, land cover and various environmental classifiers;

ii) developing a data model to implement this conceptual framework within a relational database;

iii) generation of consistent and comparable descriptions of *a priori* (extant) land classifications, in the form of database entries;

iv) demonstrating and testing the feasibility of inter-comparing these *a priori* classifications by matching these database records;

v) building prototype reference classifications of land use and land cover, drawing on current practice and on the same conceptual principles that underpin the database design.

Although the immediate purpose in developing this database was to facilitate the inter-comparison of *a priori* land classifications, the same software is also intended for the entry, storage, management and analysis of information on land use (for example, collected from questionnaire survey or interview) or on land cover (for example, collected from field survey or remote sensing). The database is an evolution of the Land Use Database, developed for FAO using a relational model by ITC (de Bie, 1996). The land use data entry modules are complete and fully tested, while those for land cover presently exist only as design specifications, since it was never intended to acquire actual data on land cover as part of this study. However, ongoing discussions with the AFRICOVER Project Team are intended to lead to complete implementation of the land cover aspects of the database design, in a form that is appropriate to handle data from the AFRICOVER programme.

4.1. Data Model

The land use and the land cover modules of the database utilize a similar data model containing two groups of relational database files. The first group, comprising the **Land Data Files,** contains primary or secondary information, collected, for example, from surveys of land use, from field survey or from remote sensing. The second group, **Land Classes,** contains information on *a-priori* classes, including the class names, their hierarchical relationship (if any) within the classification and the classifiers used to define the classes. A third database consists of a single file and is referred to as the **Glossary**. It contains parameter values used in the Land Data Files and Land Classes. All three databases are linked to each other. The file structure of the databases in the land use module, and their internal and external links is shown in Figure 10.

4.2. The Land Use Data Model

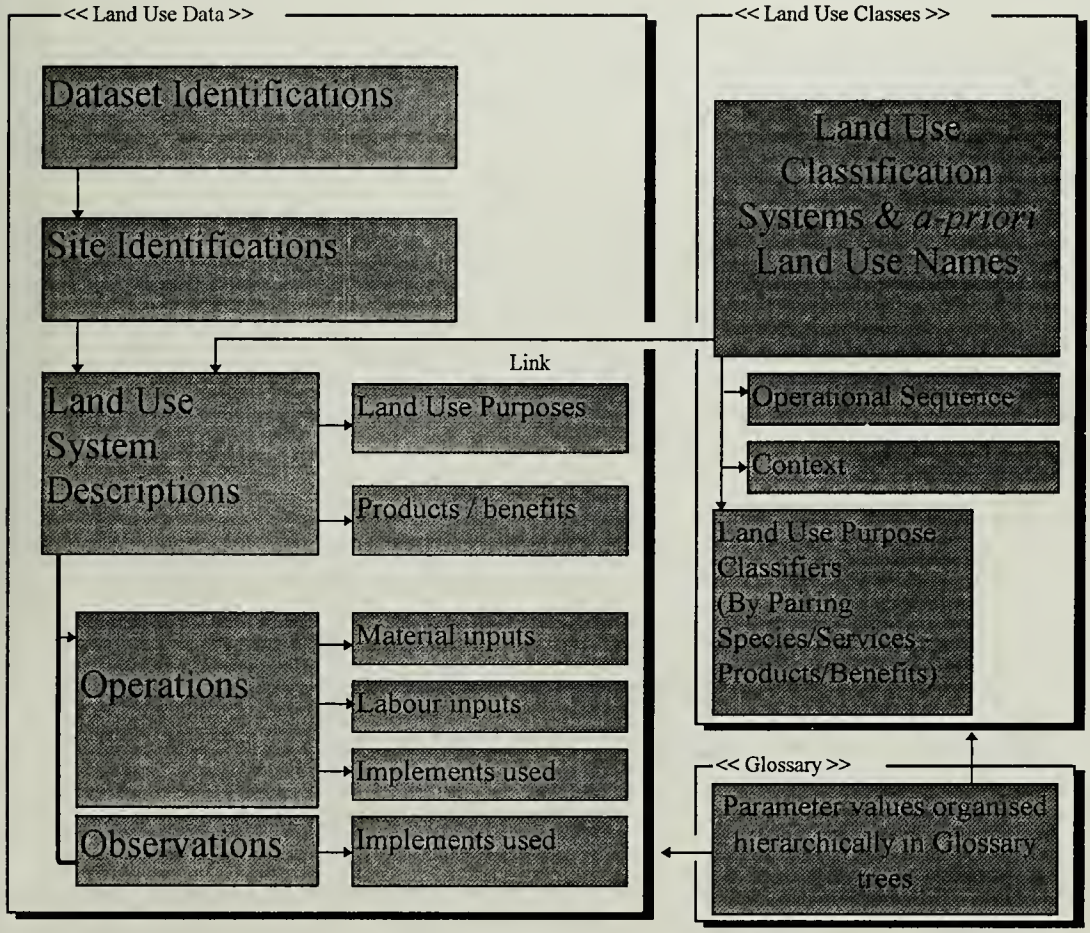
This is described in much greater detail in de Bie et al. (1996).

The Land Use Database employs three types of classifiers to identify **land use data** or to define **land use classes** (Figure 10):

i) Land Use Systems are characterized by *Purpose classifiers,* which describe the material outputs (Products) or the intangible results (Benefits) from a land use system. Purpose classifiers consist of paired combinations of terms describing the [Species/Service Product/Benefit] combinations aimed at. Examples could include grains from maize or straw from wheat (tangible products), shade provided by trees, soil protection by cover crops, pleasure by recreation, or bio-diversity conservation through protection (intangible benefits). For each land use class at least one combination must be specified.

ii) Operation sequence classifiers specify the operations that lead to an intended product. For example, cereal crop production might involve the sequence 'Ploughing, Seeding, Weeding, Application of fertilizer, Harvesting, Fallow'.

Figure 10 Data Model of the Land Use Database.
Each block represents one database file; links between the Glossary File and other files are not depicted.



iii) *Context classifiers* specify the circumstances of a land use system. They are not an inherent part of the purpose or operation sequence. It is basically incorrect to use context aspects as classifiers. They are included in The Land Use Database as a compromise because they are frequently used in existing classification systems. Context classifiers can be grouped into three types:

- Origins of inputs / implements and destinations of outputs. This type of classifier is useful when a classification system includes "market orientation".
- Tenancy arrangements.
- Others, referring, for instance, to 'capital intensity', 'holder attitude', and 'goals of holder'.

4.3. Land Cover Notation

As indicated above, land use can be defined on the basis of inputs, products and activities. In the case of land cover, no such underlying common principle has previously been identified. Land cover has been defined in the past, using a mixture of different types of characteristics. Frequently cover has been divided into Vegetated land, Bare ground or Water, and Built-on Land. Vegetation is often defined on the basis of structure or species, whereas man-made constructions are often differentiated on the basis of purpose.

4.3.1. Land Cover Attributes

Land cover is described by observations or measurements of characteristics made either on the total set or on a specified sub-set(s) of land-cover features at a given site at a given moment. As we have indicated earlier (Section 2.4.4.2), these features include the soil surface, water, bare rock or sand, vegetation and man-made surfaces and constructions.

We have developed a land-cover notation, founded on the assumption that it is possible to describe any type of land cover by specifying i) constituent feature sub-sets and ii) observed or measured characteristics of those sub-sets. For example, a description of the land cover 'Shrub Savannah' might identify the sub-sets 'Shrubs' and 'Herbaceous Vegetation'. Associated with each, there might be observations of proportional canopy cover, or mean canopy height. Together, the identity of the sub-set and the associated measurement (e.g. 'Tree crown' + 'Diameter') constitute a distinguishing characteristic, or **attribute** of a site or of a land cover class.

The notation must accommodate both qualitative and quantitative variables (e.g. 'Canopy cover: dense', '10%<Canopy cover<50%'). In the case of quantitative values, the unit of measurement must be specified.

4.3.2. Types of sub-set

Land cover may sometimes be described by observations or measurements for the whole set of features at a site. An example of this might be the measurement of total biomass. More frequently however, it is characterised by observations on a number of sub-sets of land cover features. These sub-sets may be defined in two ways:

i) sub-sets of land-cover features, whose members are structurally-, morphologically- or taxonomically-related entities. For example, a sub-set of all objects called 'Trees', or of all objects belonging to the species *Erica tetralix*.

ii) sub-sets identified on the basis of their location within a sub-space of the complete site, defined in terms of x-, y- and z- co-ordinates. Sub-sets in the z-dimension are frequently used to segment the vertical structure of vegetation. For example the description of vertical vegetation structure (physiognomy) is based on estimates of plant cover in a number of layers. Spatial segmentation in the x, y domain is less common.

Sub-sets may be defined at various levels of aggregation. The sub-set *Erica tetralix* includes the objects belonging to this species. The non-taxonomic sub-set 'Dwarf shrubs' or the taxonomic sub-set *Ericaceae* represent higher levels of aggregation, inclusive of other species. Still higher aggregation levels like dicotyledons (taxonomic) or woody species (non-taxonomic) allows membership of the sub-set to be further expanded.

Some classification systems define sub-sets using both spatial criteria and by objects. For instance, classification systems for vertical vegetation structure specify the presence of different life forms (e.g. woody *versus* non-woody species), in different canopy layers (z-dimension). Our land cover notation has been designed to allow sub-sets to be defined in terms of just such hybrid criteria.

4.3.3. Mixed Land Cover Types

Note that the notation imposes a parametric approach to the description of land cover classes. Sites, (or land units) are described in terms of the presence of a number of sub-sets of land-cover features. If the land cover is homogeneous, there may be only one sub-set; if the cover is mixed, then all significant sub-sets should be recorded.

When the land-cover features are randomly dispersed within the site, sub-set descriptions are valid for the whole site and it can be treated as a single land-cover type. However, the distribution of objects often shows a recognisable spatial pattern. In this case, which we refer to as 'Pattern Stratification', the site consists of more than one cover type. The land cover database been designed to allow the storage of data from sites which exhibit pattern stratification. This is achieved by defining cover types as percentages of the whole site area and by noting the observations / measurements for each cover type independently.

4.3.4. Measurements on part of the sub-set

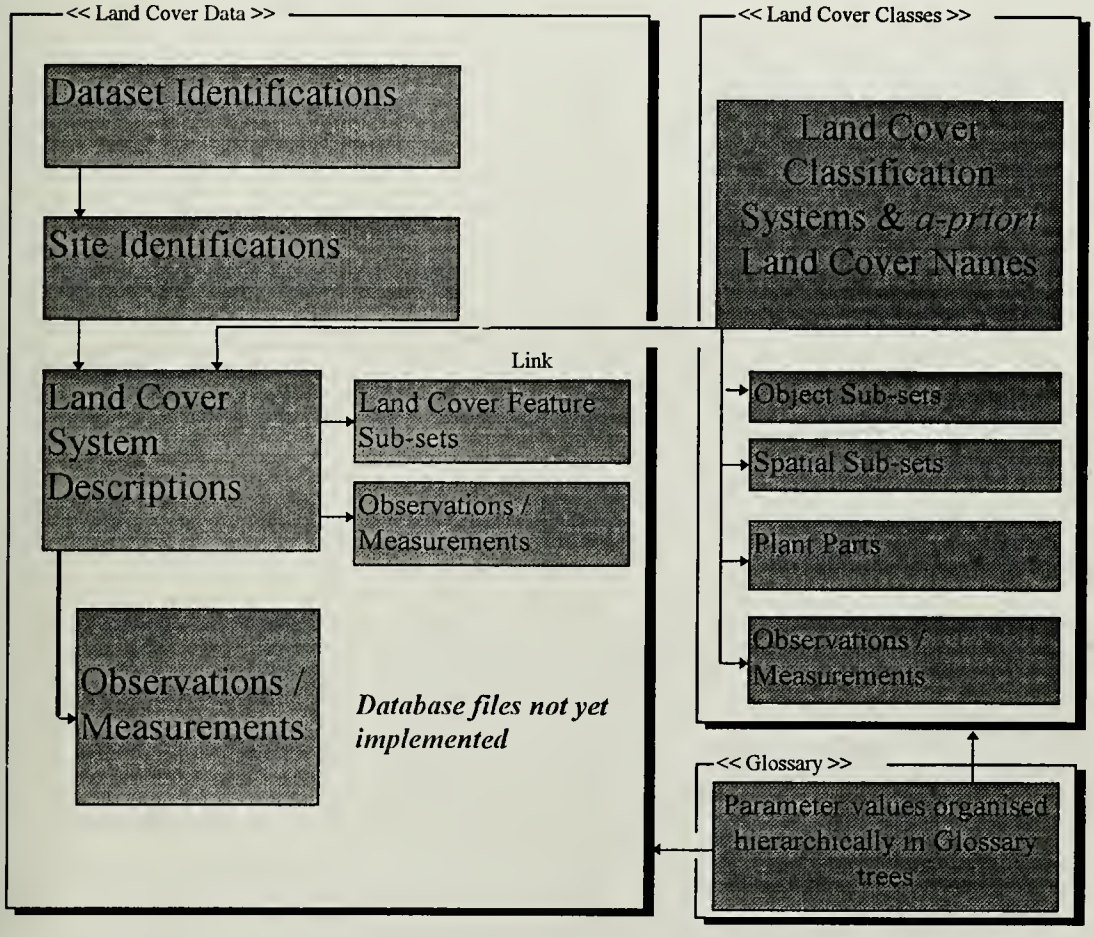
Frequently, measurements or observations are made on part of the sub-set instead of its whole. Consider, for example, the case where broad-leaved trees have been identified as the sub-set to measure biomass. One may decide to determine the biomass for the trees as a whole. However, it is equally likely that the biomass of specific parts of the trees, such as the leaves, is of interest. The notation therefore allows observations to refer either to the whole sub-set (broad-leaved trees) or to part of the selected sub-set (the leaves of the broad-leaved trees).

The above approaches ensure that the land cover notation is scale-independent. For example: one may describe at national level the sub-sets: forest, built-up and fields, or at field level: bunds, road verge and bare soil. Note that the site can be geo-referenced, but the sub-sets are not.

4.4. The Land Cover Data Model

The file structure of the land cover database is identical to that of the land use system (see Figure 11).

Figure 11 Data Model of the Land Cover Database



The design envisages three database files, holding:

i) *land cover data.* This will store records of observations and measurements of chosen sub-sets of land cover features, made in the field or from remote sensing. The land cover **data** file has not yet been implemented.

ii) *land cover classes.* This file stores descriptions of a priori land cover classes, expressed in terms of their attributes (observations and measurements of sub-sets of diagnostic land cover features).

iii) *land cover glossary*. A single file, linked to the other land cover database files and performing the same functions of nomenclature control as the land use glossary (see Section 4.5).

4.4.1. Representation of land cover classes

We proposed above that land cover classes should be represented by a sub-set of land-cover features, capable of observation or measurement. Within the above data model, classes are recorded in the following way:

- Each land cover class is represented by one or more **Definitions**.

- A **Definition** comprises one or more **Subsets,** associated with one or more **Rules.** The sub-sets identify the land cover features which the class contains; the rules describe the observations or measurements of those sub-sets, and the boundary conditions. These might specify a particular condition, either qualitatively or quantitatively (eg COLOUR = GREEN, pH = 7.0) or, more commonly, may define thresholds in terms of upper and / or lower values.

Figure 12 provides examples of how this notation is used in practice. All the examples are taken from UNESCO (1973).

The first (and simplest) example, describing the category '*Scrub*' requires a single **definition**, which comprises one physiognomic subset - 'Shrubs' and one **rule** - height between 0.5 and 5.0 m. For membership of this class, both sub-set and rule must apply.

The second example, '*Tall forb communities*', also employs one definition containing a single subset - 'Forbs'. However, there are three rules which define thresholds of height and cover and growth stage. For class membership, all three rules must be satisfied.

The third class, '*Extremely xeromorphic (subdesert) shrubland*' also involves a single definition, but this time the definition consists of several sub-sets and a number of rules. One sub-set - 'Stem succulents' is based on a single physiognomic criterion; the remainder are composite and involve criteria relating to both physiognomy ('Shrubs') and leaf type ('Sclerophyllous', 'Leafless', 'Microphyllous'). Again, there are three rules, this time defining conditions of habit, cover and height. Class membership is satisfied if any of the four sub-sets is present, provided that all rules are met.

The fourth class, '*Tropical & Subtropical Evergreen Seasonal Forest*', introduces the need for multiple definitions. The first definition specifies the dominant presence of evergreen broad-leaved trees. (Note the use of composite criteria relating to physiognomy ('Trees'), leaf seasonality ('Evergreen') and leaf shape ('Broadleaved') in defining the subset). The second definition specifies the occasional presence of deciduous trees. For class membership to be satisfied, all definitions must be satisfied.

These examples all utilise *object-based* sub-sets. In other words, the sub-sets comprise features defined on the basis of their *properties*. Section 4.3.2 shows how it is possible to define sub-sets on the basis of vertical strata within a vegetation canopy.

Figure 12 Representation of land cover classes using definitions, based on sub-sets and rules

A-Priori Land Cover Classification Systems
Unesco - Int. Classif and Mapping of Vegetation

Class Code : 15
Class Name : Scrub (shrubland or thicket)
- Definition
  - Subset: Shrubs
  - Rule: Quantitative height is between 0.50 - 5.00 m

Class Code : 5
Class Name : Tall Forb Communities
- Definition
  - Subset: Forbs
  - Rule:
    - Quantitative height is larger than 1.00 m
    - Time, Age, Age, qualitative, Mature
    - Cover percentage is larger than 50.00 % of Area

Class Code : 15
Class Name : Extremely xeromorphic (subdesert) shrubland
- Definition
  - Subset:
    - Shrubs AND Sclerophyllous
    - Shrubs AND Leafless
    - Shrubs AND Microphyllous
    - Stem succulents
  - Rule:
    - Habit, Xerophytic
    - Cover/quantity, Cover, Crown spacing, Crowns not touching
    - Quantitative height is between 0.50 - 5.00 m

Class Code : 10
Class Name : Tropical & Subtropical Evergreen Seasonal Forest
- Definition
  - Subset: Trees AND Evergreen AND Broadleaved
  - Rule:
    - Cover/quantity, Cover/abundance scales, Codom scale, dominant
    - Cover/quantity, Cover, Crown spacing, Crowns interlocking
    - Quantitative height is larger than or equal to 5.00 m
- Definition
  - Subset: Trees AND Deciduous
  - Rule: Cover/quantity, Cover/abundance scales, DAFOR, Occasional

---

To summarise the above rules:

- Each category in a classification system is represented by one or more **Definitions**.
- A **Definition** comprises one or more **Sub-sets**, associated with one or more **Rules.**

- All **Definitions** that are entered must be satisfied for the condition to be met. (i.e. Boolean **AND** applies between Definitions).

- A **Sub-set** may include multiple criteria; in this case, Boolean **AND** applies between the criteria.

- When a **definition** invokes several **Subsets,** Boolean **OR** applies. (i.e. if any one Subset is present, then the condition is **TRUE**)

- Within a **Rule,** all the conditions must be satisfied (ie Boolean **AND** applies).

Each **Rule** applies to the logical union of all the **Subsets** with which it is associated. Clearly, the notation is very flexible and potentially complex. However, experience has shown that most class definitions require quite simple combinations of rather few simple definitions.

4.5. The Glossary

The Glossary is a structured list containing the terminology needed to describe the various distinguishing features of land units indicated above. Its main function is to control the values used to describe variables held in the database, and to ensure consistency of terminology. For example, the selection procedure avoids typing errors and spelling differences and can ensure that quantitative variables are within defined limits. It also provides a means of generating on-screen menus to facilitate the selection of appropriate values by the user. The Glossary encourages users to document formal definitions of the terms used; these definitions are available for on-line inspection. The hierarchical structure of the Glossary allows parameter values to be specified at the level of detail required (from general to more specific). In constructing database queries, this permits enquiries to be made progressively more, or less restrictive by moving up and down the hierarchy.

The Glossary file is linked to all other database files (this linkage is not shown in detail in Figures 10 and 11). Because it is needed by all the database modules, it must include concepts appropriate to the description of land use, land cover and any other components of the ecosystem database. To achieve this, the glossary is organised into a number of hierarchical "trees". Its overall structure is shown in Figure 13. The following Sections of the Report describe sequentially more detailed aspects of the glossary in relation to land use, land cover and general concepts.

Figure 13(a) Overall Structure of Glossary

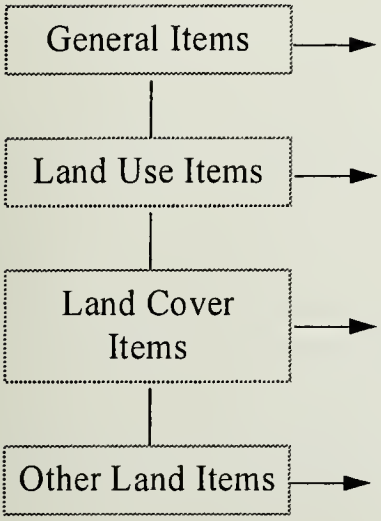


Figure 13 (b) Structure of Glossary Tree 'General Items'

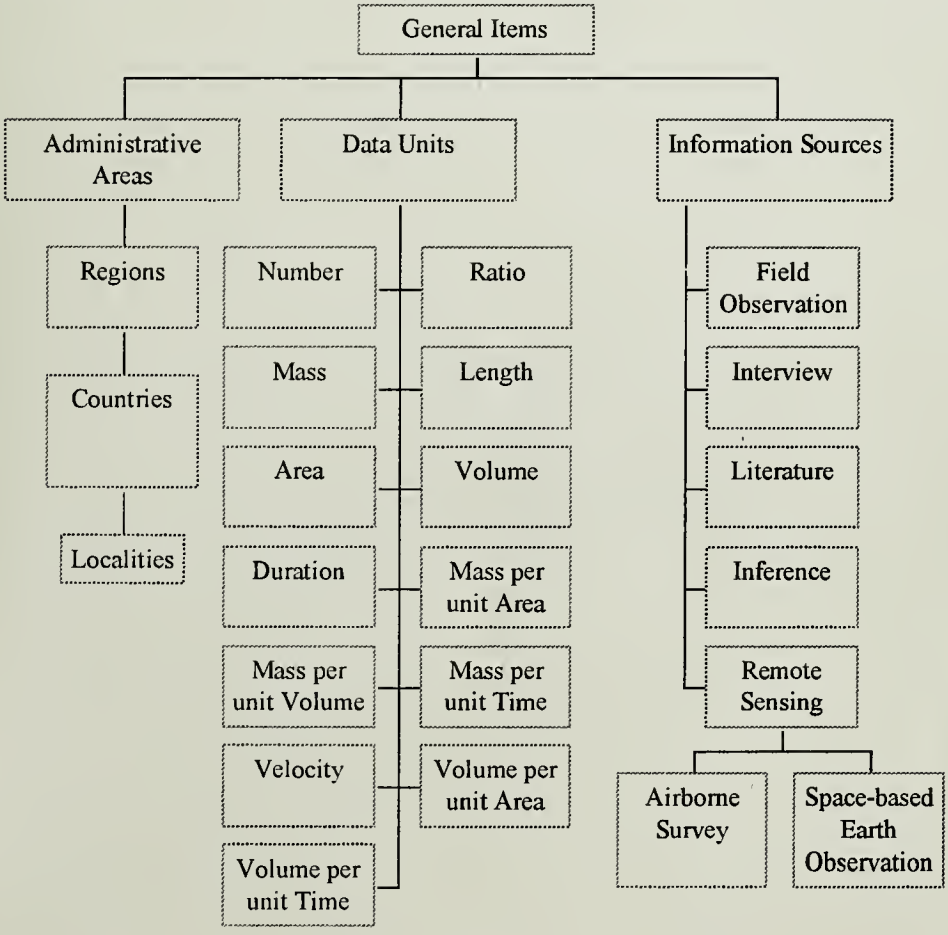
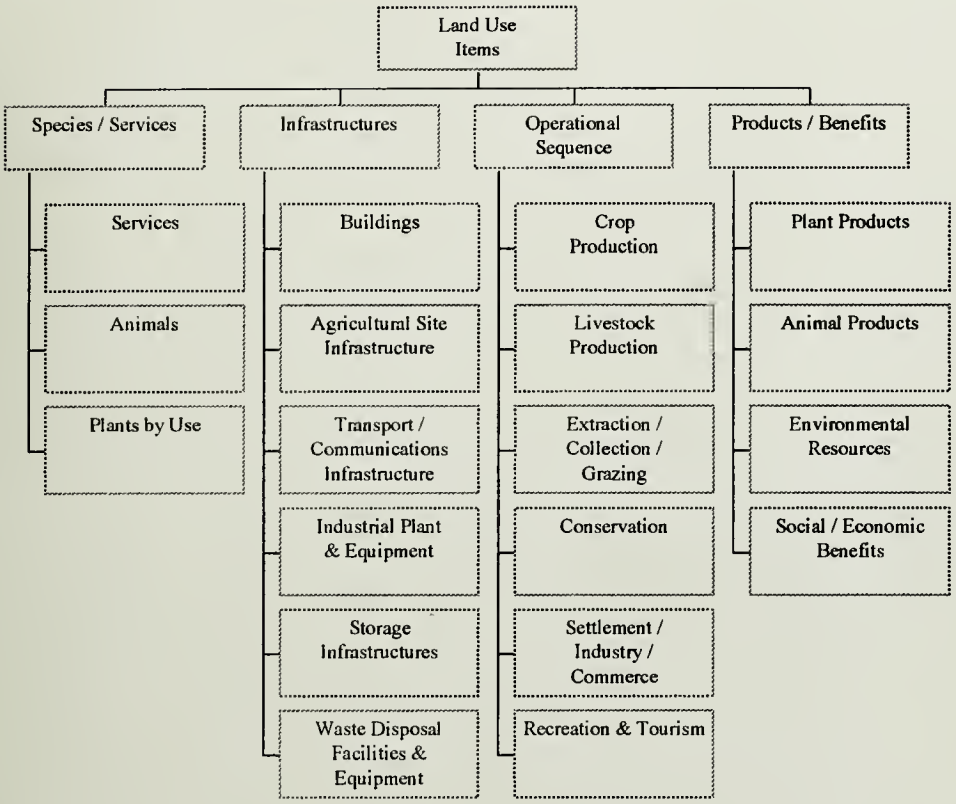


Figure 13 (c) Structure of Glossary Tree 'Land Use Items'



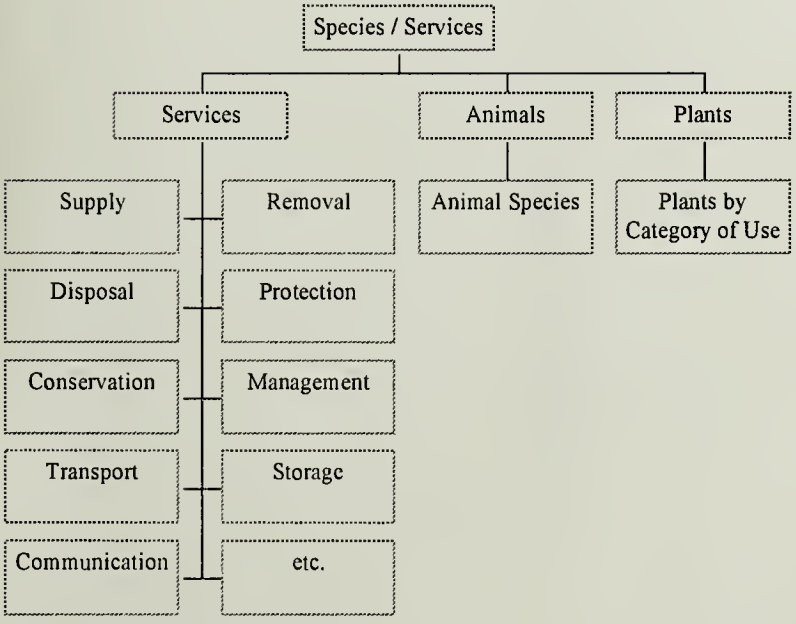


Figure 13 (c) Structure of Glossary Tree 'Land Use Items'

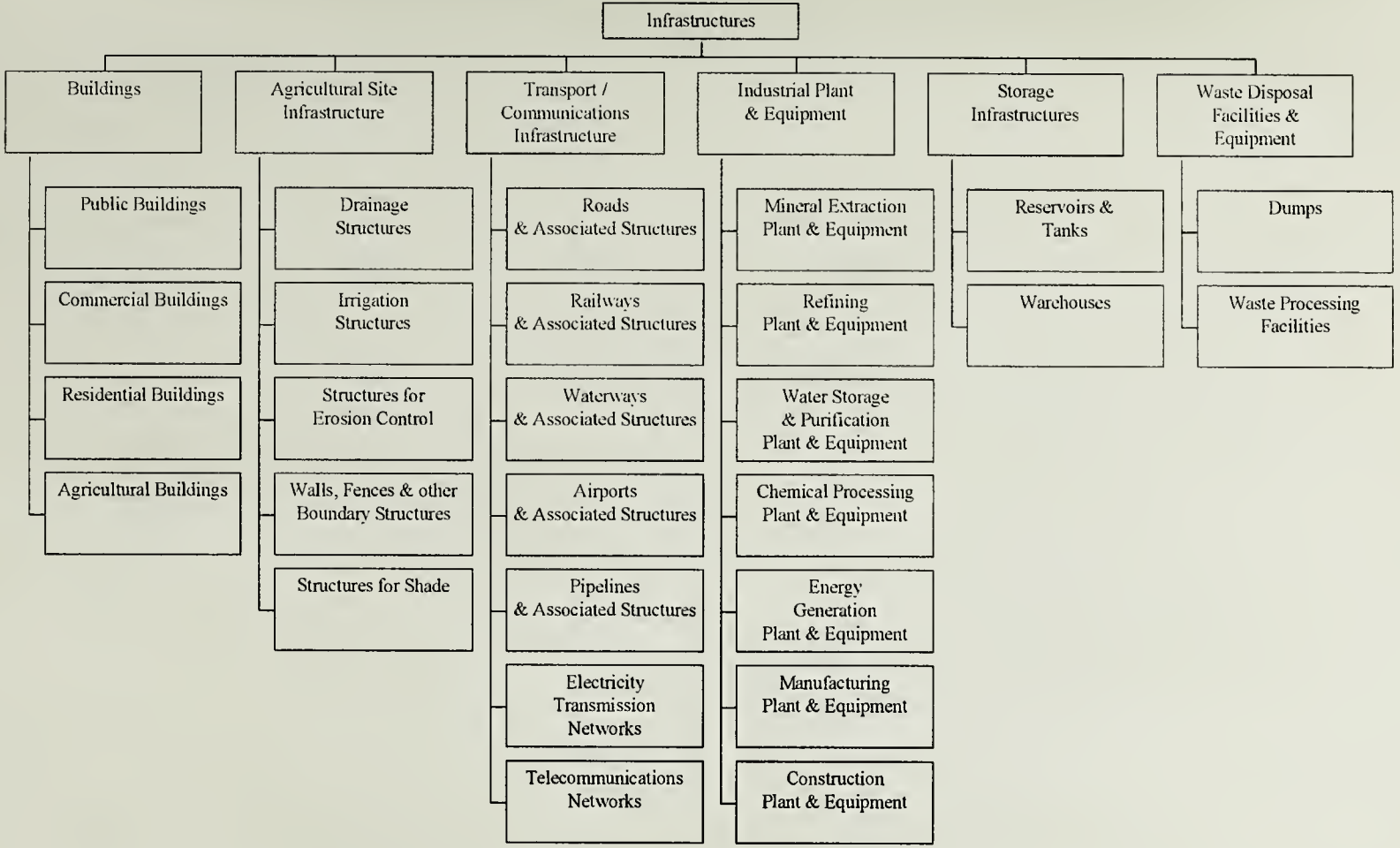


Figure 13 (c) Structure of Glossary Tree 'Land Use Items'

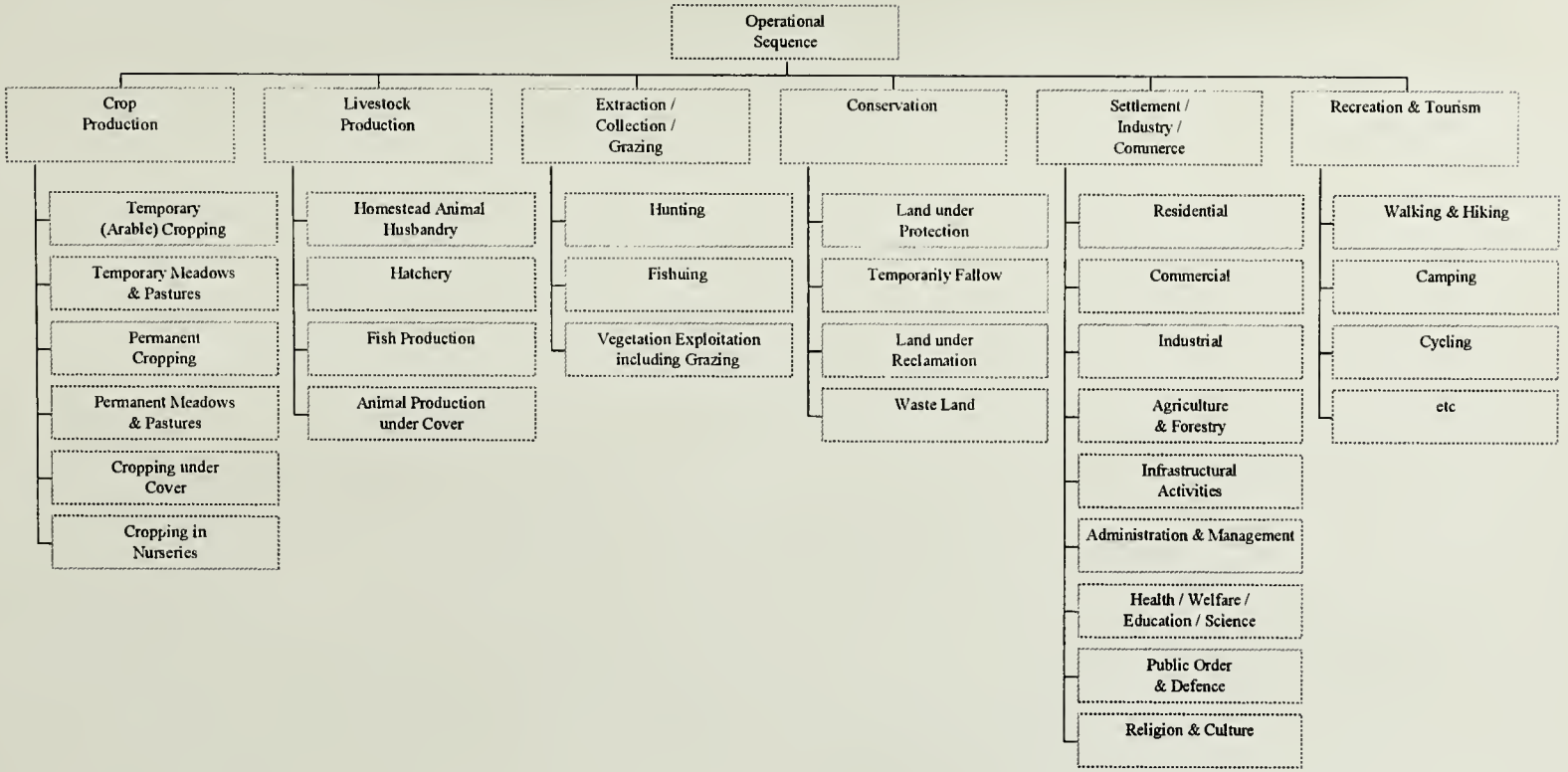
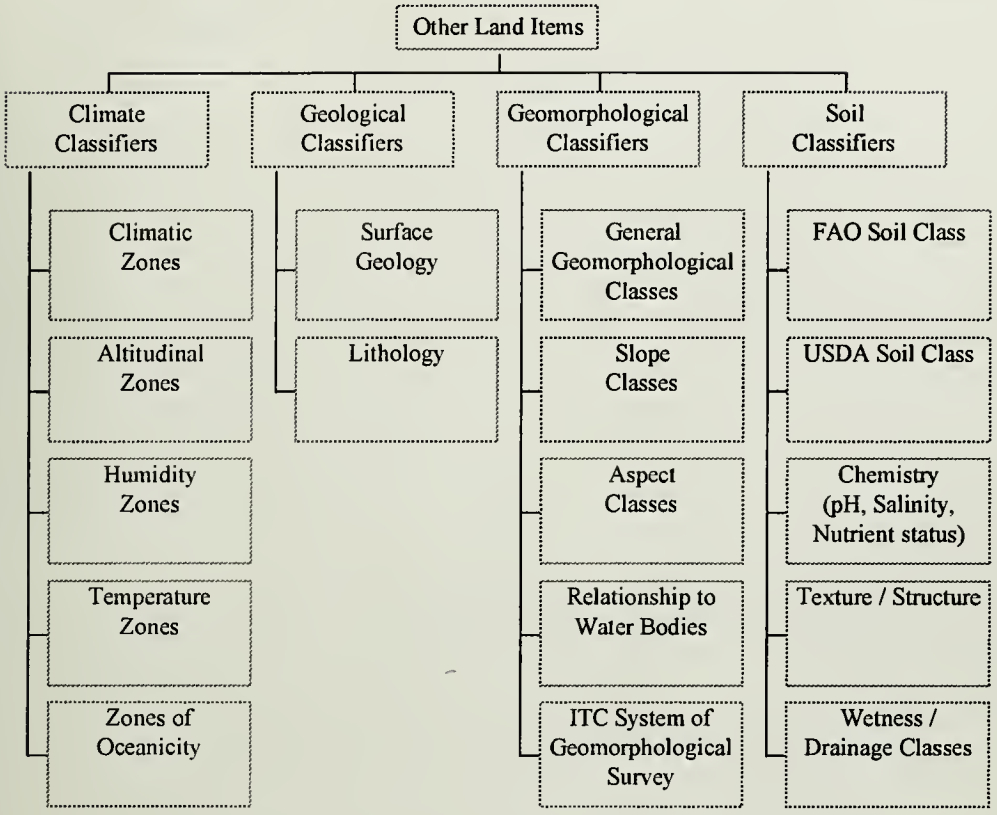


Figure 13 (c) Structure of Glossary Tree 'Land Use Items'

Figure 13 (d) Structure of Glossary Tree 'Other Land Items'



4.5.1. The Land Use Glossary

The complete Land Use glossary (described fully in de Bie *et al.*, 1996) consists of 19 glossary "trees" (see Figure 14 and Annex 2). Of these, only four trees were required to characterise *a priori* classifications in the present study. These were those describing Species and Services, Products and Benefits, Operational Classifiers and Infrastructures. In each tree, glossary items are hierarchically structured, from general to specific. Figure 15 illustrates the hierarchical structure of the glossary tree Products / Benefits / Materials.

It is important that glossary items are used in the same way by different users; this requires clear and unambiguous definition of each item. Each glossary item can be documented in a 'help' screen that may be invoked whenever the item is accessed, using a function key (<F1>). The documentation of a glossary item is in free-text format; ideally, it will contain a definition of the glossary item, an explanation, and its attribution. An example of a help screen containing documentation of an operation sequence classifier is shown in Figure 16.

Figure 14 List of Land Use Glossary Trees

«Land Use Items»
- Classifiers: Context
- Classifiers: Oper.Sequence
- Tenancy Arrangements
- Infrastructures
- Species/Services
- Operation Names
- Power Sources
- Implement Origins
- Implements
- Gender & Age Classes
- Skills
- Labour Origins
- Material Inputs
- Material Input Origins
- Material Relocations
- Products/Benefits/Materials
- Quality Classes
- Product Destinations
- Observation Names

«19»

F1=Help F3=Print

Figure 15 Extract from the Glossary Tree: Products / Benefits / Materials

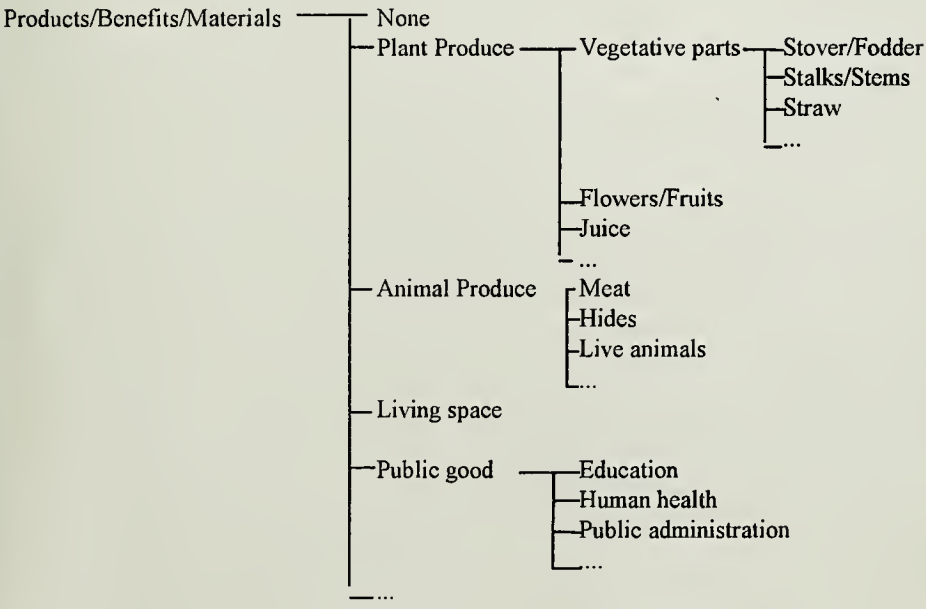


Figure 16 Use of the 'Help' facility to define terms in the Land Use Glossary

«Cultivation Factor, Shifting Cultivation;
Def.: Ruthenberg (1980): Agricultural systems which involve an alternation between (i) cropping for a few years on selected and cleared plots and (ii) a lengthy period when the soil is rested. The land is cultivated for less than 33% of the years.

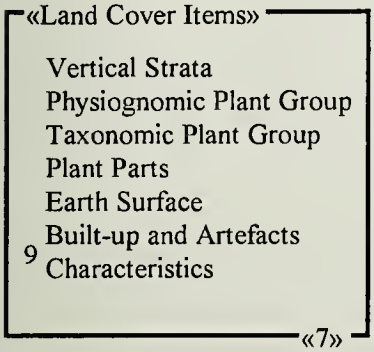
F1=Help F3=Print Esc=Exit

In addition to its function in controlling terminology, the Glossary can also be used to determine the view of the database seen by a user, for example, restricting it to a pre-defined window, chosen to reflect his specialist interest by filtering out at the data entry stage items which are of no relevance.

4.5.2. The Land Cover Glossary

The Land Cover glossary consists of 7 glossary "trees" (see Figure 17). Its purpose is similar to that of the Land Use Glossary, but it contains the terminology needed for the representation of land cover classes, as described in Section.

Figure 17 List of Land Cover Glossary Trees



F1=Help F3=Print

The first six glossary trees contain the terminology needed to define sub-sets of land cover features.

The tree "Vertical Strata" contains descriptive criteria for defining spatial sub-sets. (A quantitative means of vertical segmentation is possible within a database record by indicating lower and upper height limits: this does not require access to a glossary).

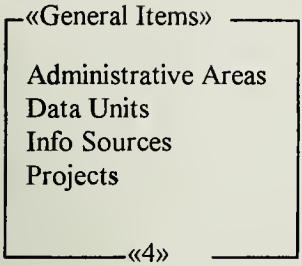
The trees "Physiognomic Plant Group" and "Taxonomic Plant Group" define morphological and taxonomic sub-sets of vegetation. "Plant Parts" contains terms to identify plant components (leaves, bark, roots), where observations are made on part of the sub-set, rather than the whole. The trees "Earth surface" and "Built-up and Artefacts" contains similar terminology to describe non-vegetated land cover.

The final tree "Characteristics" provides the means of defining Rules which define the observed or measured characteristics of the recorded sub-sets.

4.5.3. General glossary trees

In addition to the sets of glossary trees required to manage the specialised terminologies of land use and land cover, there are four trees containing more general terms, applicable across all the different database modules. These general glossary trees are shown in Figure 18.

Figure 18 List of general glossary trees



F1=Help F3=Print

The tree "Administrative Areas" contains a general terminology for defining geographical context in terms of countries, regions and localities; the tree "Data Units" contains units of measurement; the tree "Info Sources" is intended to allow the origins of data to be identified in generic terms (e.g. field survey, questionnaire, interview, remote sensing). Finally, the tree entitled "Projects" allows datasets to be flagged according to the project or programme of origin.

CORRELATION OF *A PRIORI* LAND CLASSES

5.1. The Need for a Correlative Approach

The argument for improved compatibility of information about the land surface has already been made (Section 2, pp 2-3). Surveys of land use or land cover are both expensive and difficult to undertake. Change detection and monitoring require inter-comparison of data collected at different times, often by different organisations and / or using different methods. Compilation of national, regional or global data on land use frequently depends on re-interpretation of data collected more locally.

There are many impediments to the assimilation of land data from different sources. Differences in the methods used for data acquisition (e.g. remote sensing *vs* field survey; interview with land holder *vs* reliance on documentary evidence), differences in sampling methods and differences in data storage and representation (e.g. maps *vs* statistical tabulations) all introduce difficulties in comparing estimates of land use or land cover from a variety of sources. Arguably the greatest potential for error originates in differences in the classification systems used to record information on land use or land cover. Examples have already been given of how differences in classification can influence both estimates of the areal extent of different land cover types (Figure 1) and their mapping (Figure 2). We ruled out (on grounds of feasibility) solutions to this problem based on the imposition of common standards (Section 2.3). Instead, we advocate development of methods to allow statistics defined in terms of a particular classification to be transformed into the reference frame of alternative systems.

5.2. A Basis for Correlation

Such methods of transforming data between classifications should, as far as possible, be accurate, objective and repeatable. An important consideration is to avoid, or at least, to minimise, variation due to different human interpretations. There are three possible approaches to the task of correlation:

- by use of human experts (or expert systems, which provide a codification of human knowledge) to identify equivalent classes in the different classification systems, using their experience and knowledge of the subject matter. This was the approach adopted in the earlier UK-based study (Wyatt *et al.*, 1994).

- by reclassifying the original survey data, if these are available, in terms of the new classification.

- by deriving, or inferring one set of classifiers from the other, using a natural relationship between them, for example, on the same principle as the use of pedo-transfer functions in soil classification and mapping.

The first approach necessarily contains elements of subjectivity, and results are likely to vary, depending on the judgements of the experts employed. The second, in principle, may be objective, but is likely to be difficult or expensive to implement. The third approach forms the basis of the method used in this study. In this method, the natural relationships between land classes are the attributes of land use and land cover, which underpin the data models described in Section 4 of this Report.

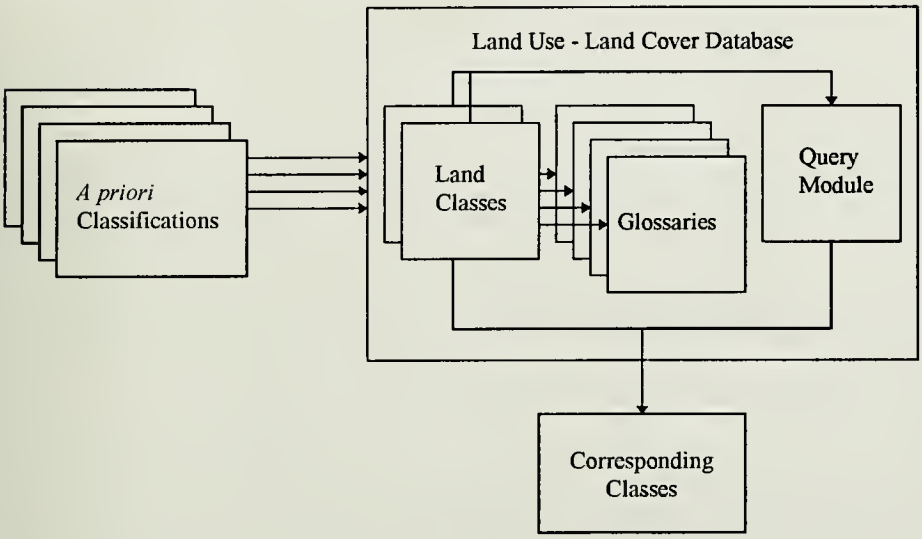
5.3. Overview of Correlation Procedures

Within the Land Use Database (de Bie *et al.*, 1996), is the capacity to describe *a priori* land use classifications in terms of key attributes, including the sequence of land management operations undertaken, the intended outputs, the species and services, etc. (see Section 4.2. The Query Module of the Land Use Database provides the means to match the attributes used to describe a given *a priori* land use class against other similarly encoded classes and to identify classes with similar, or identical characteristics. This system was therefore adopted as the prototype to demonstrate the principles underlying our approach to the inter-comparison of land classifications.

An important element of the present study was the development, described in Sections 4.3 - 4.4 of this Report, of a Land Cover Module within the same database software. The Land Cover Module can also be used to characterise *a priori* classes, but this time in terms of attributes of land **cover**. These attributes of land cover include vegetation, by physiognomy or taxonomy, earth surface properties, artefacts and features of the built environment and abstract qualitative and quantitative characteristics, such as spatial and temporal properties, morphology and composition. Logical combinations of land cover attributes can be used to search a file of a priori classes to match those with similar land cover characteristics, just as when matching sets of similar land use classes.

In the prototype, the land cover and land use modules are separate: inter-comparisons were on the basis **either** of land use **or** of land cover. In one respect, this was a useful discipline, since it enforced clear separation of these concepts. However, most extant classifications are less rigorous, and frequently include elements of land use, land cover and other environmental 'ecosystem' attributes, such as climate or geography. Clear definition and identification of such composite classes solely on the basis of land use or land cover sometimes made for difficulties, as will become apparent in the following Sections of the Report.

Figure 19 Application of Land Use - Land Cover Database to Describe *a priori* Land Classes and to Identify Similar Classes by Matching Attributes



The overall approach employed is illustrated in Figure 19. The first step was to select from the large number of land classifications in current use world-wide a subset of those to be included in the prototype. In the second stage, a systematic record of the constituent classes of each classification was entered in the land use - land cover database, in the form of structured lists of their characteristic attributes of land use or land cover. This analysis was carried out by reference to published definitions. The same analysis frequently identified shortcomings in the glossaries, and the opportunity was taken to revise and expand them. In the case of the land use system, the glossaries were already extensive and well-tested, and the main change was to expand the sections concerned with the built environment. In the case of the newly-developed land cover system, this exercise was an important step in populating the glossaries.

5.4. Choice of Classifications

The term 'classification' was taken to mean any nomenclature, hierarchical or non-hierarchical, which is capable of being used to describe land cover or land use. Important examples of such classifications in current or recent use world-wide were identified by means of a review of the technical and scientific literature, building on documentation produced for the 1993 UNEP/FAO Expert Meeting on Harmonising Land Cover and Land Use Classifications (UNEP/FAO, 1994) and on a preliminary list of classifications, drawn up in preparation for the present study. The resulting Bibliography forms Annex 3 to this Report. Detailed documentation has been assembled for as many as possible of the classifications identified in the review; this includes the classifications themselves and, where possible, definitions of the land cover or land use categories employed and relevant bibliographic citations. This documentation is held by ITE at its Monks Wood site.

The following criteria were applied in selecting from this list the classifications to be included in the prototype. The aim was to assemble information on as wide as possible a range of such classifications, covering:

- a diversity of geographical scales and settings, including: global, continental, regional (temperate), regional (tropical), regional (arid), national, and farm level;

- a range of scientific disciplines and application areas, including bio-geography, agriculture, forestry, resource management, environmental protection, global change, biodiversity;

- a range of data capture methods (e.g. remote sensing, ground-based mapping, agricultural census such as the AD 2000 World Census of Agriculture of FAO's Statistics Division);

- a range of data processing and presentational formats (mapping, statistics and tabulation, yield estimation, etc.).

In Annex 4, the classifications listed in the Bibliography at Annex 3 are characterised according to these criteria.

5.5. Encoding of *a priori* Classifications and Population of Glossaries

This was completed for the 16 classifications listed in Table 1. 9 classifications were described in terms of attributes of land use and 9 in terms of land cover characteristics. By reference to published definitions, each land class in every classification was described in terms of elementary attributes and these attributes were entered in the land use - land cover database, using appropriate terms from the Glossary. Examples of these outputs are attached as Figure 20.

Table 1 Land Classifications Considered in the Prototype Correlation Study

Correlation by Land Use Attributes
Commission of the European Communities (1992): CORINE Land Cover
UN/ECE Statistical Division (1993): ECE Standard Statistical Classification of Land Use
Gierman, D.M. (1981): Land Use Classification for Land Use Monitoring. Environment Canada
Duhamel, C. *et al.* (1995): Classification for Land Use Statistics EUROSTAT Remote Sensing Programme (CLUSTERS)
Young, A. (1994): Towards International Classification Systems for Land Use and Land Cover (UNEP/FAO)
Anderson,J.R. *et al.* (1976): A Land Use and Land Cover Classification System for use with Remote Sensing. (USGS)
FAO (1986): Programme for the 1990 World Census Of Agriculture. (UN-FAO)
Mücher, C.A. et al. (1993): Proposal for a Global Land Use Classification (FAO)
UK Department of the Environment (1996): Land Use Information Base for England (National Land Use Stock System)

Correlation by Land Cover Attributes

USGS: Range and Forest Resources of Senegal

UNESCO (1973): International Classification and Mapping of Vegetation

US Federal Geographic Data Committee (1995): Vegetation Classification Standards

Paijmans, K. (1975): Vegetation Map of Papua New Guinea. (CSIRO)

IGBP-DIS (1996): The IGBP-DIS Global 1km Land Cover Data Set 'DISCover'

Commission of the European Communities (1992): CORINE Land Cover

Anderson,J.R. *et al.* (1976): A Land Use and Land Cover Classification System for use with Remote Sensing. (USGS)

FAO - UNEP (1994): Cambodia Land Cover Atlas, 1985/87 - 1992/93

Land Cover Working Group of the Asian Association on Remote Sensing (1995): Draft Classification.

Figure 20 Examples of Land Classes encoded in the Land Use - Land Cover Database
a) Land Use

Class Representation	Database Query
CORINE LAND COVER	
1 ARTIFICIAL SURFACES	
1.1 URBAN FABRIC	Crop Production = None
Land Use Purpose Classifiers	AND Livestock Production = None
Species/Service: Services, Buildings, Commercial Premises, ¯ -	AND Extraction/Collection/Grazing = None
Product/Benefit: Commercial Services, ¯ -	AND Conservation = None
Species/Service: Services, Buildings, Public Buildings, ¯ -	AND Settlement/Industry/Commerce = Yes
Product/Benefit: Public Good, ¯ -	AND
Species/Service: Services, Buildings, Residential Buildings, ¯ -	((Species/Service = Commercial Premises
Product/Benefit: Living Space, ¯ -	AND Product/Benefit = Commercial Services)
Species/Service: Services, Infrastructures, ¯ -	OR
Product/Benefit: Transport, ¯ -	(Species/Services = Public Buildings AND
Operation Sequence Classifiers	Product/Benefit = Public Good)
1 : Crop Production, None	OR
2 : Livestock Production, None	(Species/Services = Residential Buildings AND
3 : Extraction/Collection/Grazing, None	Product/Benefit = Living Space)
4 : Conservation, None	OR
5 : Settlement/Industry/Commerce, Yes, ¯ -	(Species/Service = Infrastructures AND
	Product/Benefit = Transport))
1 ARTIFICIAL SURFACES	
1.2 INDUSTRIAL, COMMERCIAL & TRANSPORT UNITS	
1.2.1 Industrial or Commercial Units	Crop Production = None
Land Use Purpose Classifiers	AND Livestock Production = None
Species/Service: Services, Buildings, Commercial Premises, ¯ -	AND Extraction/Collection/Grazing = None
Product/Benefit: Commercial Services, ¯ -	AND Conservation = None
Species/Service: Services, Buildings, ¯ -	AND Settlement/Industry/Commerce = Yes
Product/Benefit: Industrial Products, ¯ -	AND
Species/Service: Services, Infrastructures, ¯ -	((Species/Service = Commercial Premises
Product/Benefit: Industrial Products, ¯ -	AND Product/Benefit = Commercial Services)
Operation Sequence Classifiers	OR
1 : Crop Production, None	(Species/Services = Buildings AND
2 : Livestock Production, None	Product/Benefit = Industrial Products)
3 : Extraction/Collection/Grazing, None	OR
4 : Conservation, None	(Species/Service = Infrastructures AND
5 : Settlement/Industry/Commerce, Yes, ¯ -	Product/Benefit = Industrial Products))
1 ARTIFICIAL SURFACES	
1.2 INDUSTRIAL, COMMERCIAL & TRANSPORT UNITS	
1.2.2 Road & Rail Networks and Associated Land	Crop Production = None
Land Use Purpose Classifiers	AND Livestock Production = None
Species/Service: Services, Buildings, ¯ -	AND Extraction/Collection/Grazing = None
Product/Benefit: Transport, ¯ -	AND Conservation = None
Species/Service: Services, Infrastructures, ¯ -	AND Settlement/Industry/Commerce = Yes
Product/Benefit: Transport, ¯ -	AND
Operation Sequence Classifiers	((Species/Service = Buildings AND
1 : Crop Production, None	Product/Benefit = Transport)
2 : Livestock Production, None	OR
3 : Extraction/Collection/Grazing, None	(Species/Service = Infrastructures AND
4 : Conservation, None	Product/Benefit =Transport))
5 : Settlement/Industry/Commerce, Yes, ¯ -	

Figure 20 Examples of Land Classes encoded in the Land Use - Land Cover Database
a) Land Use

Class Representation	Database Query
2 AGRICULTURAL AREAS 2.1 ARABLE LAND 2.1.1 Non-Irrigated Arable Land Land Use Purpose Classifiers Species/Service: Plants by Use, ¯ - Product/Benefit: Plant Produce, ¯ - Operation Sequence Classifiers 1 : Crop Production, Yes, Temporary (arable) Cropping, ¯ - 2 : Livestock Production, None 3 : Extraction/Collection/Grazing, None 4 : Conservation, None 5 : Settlement/Industry/Commerce, None 6 : Recreation and Tourism, None 7 : í Water Applied, None	Crop Production = Temporary (arable) Cropping AND Livestock Production = None AND Extraction/Collection/Grazing = None AND Conservation = None AND Settlement/Industry/Commerce = None AND Recreation and Tourism = None AND Water Applied = None AND Species/Service = Plants by Use AND Product/Benefit = Plant Produce
2 AGRICULTURAL AREAS 2.2 PERMANENT CROPS 2.2.1 Vineyards Land Use Purpose Classifiers Species/Service: Plants by Use, Edible fruits and nuts, Other Families, Grapes; Vitis vinifera L., ¯ - Product/Benefit: Plant Produce, Flowers/Fruits/Seeds, Fruits, ¯ Operation Sequence Classifiers 1 : Crop Production, Yes, Permanent Cropping, ¯ - 2 : Livestock Production, None 3 : Extraction/Collection/Grazing, None 4 : Conservation, None 5 : Settlement/Industry/Commerce, None	Crop Production = Permanent Cropping AND Livestock Production = None AND Extraction/Collection/Grazing = None AND Conservation = None AND Settlement/Industry/Commerce = None AND Species/Service = *Vitis vinifera L.* AND Product/Benefit = Fruits
2 AGRICULTURAL AREAS 2.3 PASTURES Land Use Purpose Classifiers Species/Service: Plants by Use, For feed: forage/pasture/.(F1), Gramineae, ¯ - Product/Benefit: Plant Produce, Vegetative Parts,Stover/Fodder, ¯ - Operation Sequence Classifiers 1 : Crop Production, Yes, ¯ - 2 : Livestock Production, Yes, Homestead Animal Husbandry 3 : Settlement/Industry/Commerce, None	Crop Production = Yes AND Livestock Production = Homestead Animal Husbandry AND Settlement/Industry/Commerce = None AND Species/Service = Gramineae AND Product/Benefit = Stover / Fodder
3 FORESTS AND SEMI-NATURAL AREAS 3.1 FORESTS 3.1.1 Broadleaved Forest Land Use Purpose Classifiers Species/Service: Plants by Use, Timber Trees, ¯ - Product/Benefit: Plant Produce, Vegetative parts, Fire,Pole,Pulp,Timber-Wood, ¯ - Species/Service: Plants by Use, Natural Plant Communities, ¯ - Product/Benefit: None, ¯ - Operation Sequence Classifiers 1 : Crop Production, Yes, Permanent Cropping, Managed Forestry 2 : Livestock Production, None 3 : Settlement/Industry/Commerce, None	Crop Production = Managed Forestry AND Livestock Production = None AND Settlement/Industry/Commerce = None AND ((Species/Service = Timber Trees AND Product/Benefit = Fire,Pole,Pulp,Timber-Wood) OR (Species/Service = Natural Plant Communities AND Product/Benefit = None))

Figure 20 Examples of Land Classes encoded in the Land Use - Land Cover Database
a) Land Use

Class Representation	Database Query
3 FORESTS AND SEMI-NATURAL AREAS 3.2 SHRUB/HERBACEOUS VEGETATION ASSOCIATIONS 3.2.2 Moors and heathland Land Use Purpose Classifiers Species/Service: Plants by Use, Natural Plant Communities, ¯ - Product/Benefit: None, ¯ - Operation Sequence Classifiers 1 : Crop Production, None 2 : Livestock Production, None 3 : Settlement/Industry/Commerce, None	Crop Production = None AND Livestock Production = None AND Settlement/Industry/Commerce = None AND Species/Service = Natural Plant Communities AND Product/Benefit = None
4 WETLANDS 4.2 MARITIME WETLANDS 4.2.3 Inter-Tidal Flats Land Use Purpose Classifiers Species/Service: None, ¯ - Product/Benefit: None, ¯ - Operation Sequence Classifiers 1 : Crop Production, None 2 : Livestock Production, None 3 : Extraction/Collection/Grazing, None 4 : Settlement/Industry/Commerce, None	Crop Production = None AND Livestock Production = None AND Extraction/Collection/Grazing = None AND Settlement/Industry/Commerce = None AND Species/Service = None AND Product/Benefit = None
5 WATER BODIES 5.1 INLAND WATERS 5.1.2 Water Bodies Land Use Purpose Classifiers Species/Service: None, ¯ - Product/Benefit: None, ¯ - Species/Service: Services, Water Resources, ¯ - Product/Benefit: Water, ¯ - Operation Sequence Classifiers 1 : Crop Production, None 2 : Livestock Production, None	Crop Production = None AND Livestock Production = None AND ((Species/Service = None AND Product/Benefit = None) OR (Species/Service = Water Resources AND Product/Benefit = Water))

Figure 20 Examples of Land Classes encoded in the Land Use - Land Cover Database
b) Land Cover

Class Representation	Database Query
CORINE LAND COVER 1 ARTIFICIAL SURFACES 1.1 URBAN FABRIC Definition Subset : Built/artificial Rule : Cover/quantity, Presence/absence, Presence	Build-up and Artefacts = Built/artificial AND Cover Characteristics = Presence
1 ARTIFICIAL SURFACES 1.2 INDUSTRIAL, COMMERCIAL AND TRANSPORT UNITS 1.2.1 Industrial or Commercial Units Definition Subset : Built/artificial Rule : Cover/quantity, Presence/absence, Presence	Build-up and Artefacts = Built/artificial AND Cover Characteristics = Presence
1 ARTIFICIAL SURFACES 1.2 INDUSTRIAL, COMMERCIAL AND TRANSPORT UNITS 1.2.2 Road & Rail Networks & Associated Land Definition Subset : Linear constructions Rule : Cover/quantity, Presence/absence, Presence	Build-up and Artefacts = Linear constructions AND Cover Characteristics = Presence
2 AGRICULTURAL AREAS 2.1 ARABLE LAND 2.1.1 Non-Irrigated Arable Land Definition Subset : Bare soil : Plants by Use Rule : Cover/quantity, Presence/absence, Presence	(Earth Surface = Bare soil OR Taxonomic Plant Group = Plants by Use) AND Cover Characteristics = Presence
2 AGRICULTURAL AREAS 2.2 PERMANENT CROPS 2.2.1 Vineyards Definition Subset : Woody climbers AND Broadleaved AND Deciduous AND Grapes; *Vitis vinifera L.* Rule : Cover/quantity, Presence/absence, Presence	Physiognomic Plant Group = Woody climbers AND Physiognomic Plant Group = Broadleaved AND Physiognomic Plant Group = Deciduous AND Taxonomic Plant Group = *Vitis vinifera L.* AND Cover Characteristics = Presence

Figure 20 Examples of Land Classes encoded in the Land Use - Land Cover Database
b) Land Cover

Class Representation	Database Query
2 AGRICULTURAL AREAS 2.3 PASTURES └ Definition ├ Subset : Graminoids └ Rule : Cover/quantity, Presence/absence, Presence	Physiognomic Plant Group = Graminoids AND Cover Characteristics = Presence
3 FORESTS AND SEMI-NATURAL AREAS 3.I FORESTS 3.1.1 Broad-leaved Forest └ Definition ├ Subset : Trees AND Broadleaved └ Rule : Cover/quantity, Cover/abundance scales, Codom scale, dom (dominant)	Physiognomic Plant Group = Trees AND Physiognomic Plant Group = Broadleaved AND Cover Characteristics = dominant
3 FORESTS AND SEMI-NATURAL AREAS 3.2 SHRUB / HERBACEOUS VEGETATION ASSOCIATIONS 3.2.2 Moors & Heathland └ Definition ├ Subset : Non-Woody Vegetation Shrubs └ Rule : Cover/quantity, Cover/abundance scales, Codom scale, dom (dominant)	(Physiognomic Plant Group = Non-woody plants OR Physiognomic Plant Group = Shrubs) AND Cover Characteristics = dominant
4 WETLANDS 4.2 MARITIME WETLANDS 4.2.3 Inter-tidal Flats ├ Definition ├ Subset : Marine Sediments Bare rock └ Rule : Time, Frequency, qualitative, Diurnal └ Definition ├ Subset : Oceans and seas └ Rule : Time, Frequency, qualitative, Diurnal	(Earth Surface = Bare rock OR Earth Surface = Marine Sediments) AND Cover Characteristics = Diurnal AND Earth Surface = Oceans and seas

Figure 20 Examples of Land Classes encoded in the Land Use - Land Cover Database
b) Land Cover

Class Representation	Database Query
5 WATER BODIES 5.1 INLAND WATERS 5.1.2 Water Bodies Definition Subset : Fresh water Rule : Cover/quantity, Presence/absence, Presence	Earth Surface = Fresh water AND Cover Characteristics = Presence

5.6. Correlation of Classifications

The complete set of encoded descriptions of the 9 land use and 9 land cover classifications are held in the Land Use - Land Cover Database which accompanies this Report. In principle, correlations may be established between any required classes, using the Query module of this software package, as exemplified in Figure 20. At present, it is necessary to enter the class description as recorded in the database in the form of a Boolean logical expression. For example, the CORINE class 5.1.2 (Inland Water Bodies) is coded in the Land Use module of the database as follows:

Land Use Purpose Classifiers:

Species/Service: None
Product/Benefit: None

Species/Sevice: Water Resources
Product/Benefit: Water

Operation Sequence Classifiers

Crop Production: None
Livestock Production: None

The equivalent Boolean expression required by the Query module is:

Crop Production = None
AND
Livestock Production = None
AND
((Species/Service = None AND Product/Benefit = None)
OR
(Species/Service = Water Resources AND Product/Benefit = Water))

This query returns all classes from all the recorded classifications that satisfy this logical expression. Coded descriptions of land **cover** can similarly be represented by Boolean expressions, which can be used to search the database for classes with matching properties.

Annexes 5 and 6 list the outputs from two such searches for the 63 land classes which comprise the CORINE Land Cover classification (Commission of the European Communities, 1992). Annex 5 results from matching attributes of land **use**, while Annex 6 shows the output from matching land **cover**. Note that, despite its name and despite the fact that the CORINE classification was designed to accommodate land information derived from remote sensing, there are important elements of both land use and land cover in the classification. This is far from unusual amongst the classifications investigated.

The outputs listed in Annexes 5 and 6 take account of the hierarchical structure of many of the classifications considered in order to minimise redundancy in the listings. Thus, if a given class matches with a generic class X and with all its daughters (X.1, X.1.1, X.1.2, X.2, X.3, etc) then only the generic class X is listed, and matches with the sub-classes are inferred. If, on the other hand, a valid match exists only for some of the sub-classes (e.g. X.1.1, X2, X.3) then

these are listed explicitly, and the list omits the generic classes X, X.1 (which do not satisfy the query).

For example, the CORINE Land Cover Class 2 (*Agricultural Areas*) corresponds in terms of **use** to Class 2 (*Agricultural Land*) in the Anderson system and, by inference, with the sub-Classes 2.1 (*Cropland & Pastures*), 2.2 (*Orchards*, et.), 2.3 (*Confined Feeding Operations*) and 2.4 (*Other Agricultural Land*). In contrast, CORINE Class 1.2.2 - *Industrial or Commercial Units* corresponds with UN/ECE Classes 3.2 (*Industrial Land*) and 3.4 (*Commercial Land*), but not with Class 3 (*Built-up and Related Land*) because there is no match with sub-Classes 3.1 (*Residential Land*), 3.3 (*Quarries*, etc.), 3.5 (*Land used for Public Services*), etc.

5.7. Appraisal of the Results of the Prototype Correlation

Objective appraisal of the effectiveness of the methodology is difficult, since no baseline exists against which to assess the results. Two broad types of error may be recognised;

- errors of commission, or precision errors, where matches are suggested which the class definitions do not support;

- errors of omission, or recall errors, where valid matches are missed by the system.

Precision errors are relatively easy to detect, by inspection, though careful investigation often reveals valid reasons for apparently erroneous results. For example, CORINE Class 1.4.2 (*Sport & Leisure Facilities*) has **cover** attributes equivalent to '*Herbaceous Steppes*' in the USGS map of Range and Forest Resources in Senegal and to '*Agricultural Land - Grass Crops*' in the classification of the Asian Association on Remote Sensing. Recall errors, which, for reasons discussed below, may be more prevalent, are comparatively difficult to detect, unless the source documentation is itself inspected; this task rapidly becomes impossible as the number of classifications of interest increases above two or three.

5.8. External Factors that may Influence Correlation

5.8.1. Quality of the Definition of *a priori* Classes

Success in establishing correspondence between classes in different *a priori* classifications is crucially dependent upon the clarity with which these classes are defined and the consistency with which the definitions are applied in the original classifications. It goes without saying that a successful classification must identify categories that are useful in the context of the applications envisaged. In addition, it is desirable that it should be capable of being applied consistently by different users and repeatably over time. Ideally, the classes used should be **unique** and **unambiguous**. On the evidence of this study, standards in this respect are variable. Some definitions are comprehensive, and define rigorous boundary conditions, often quantitative, which mean that, in principle at least, they provide a basis for objective and repeatable classification. In other cases, definitions provide insufficient detail to achieve these goals. Sometimes, classes are identified by little more than their names; frequently, such definitions as are provided fail to define boundary conditions and are therefore open to misinterpretation. Classifications may fail to provide even internal consistency. Note, for example, the frequency with which classes in the CORINE system overlap with other classes elsewhere in the same classification.

The adequacy, or otherwise, of definitions brings into question whether, in identifying class attributes, we should depend solely on the information provided in the definitions. For example, definitions such as '*Consist mainly of broad-leaved evergreen trees*' beg the question of how to interpret '*mainly*'. In cases such as this, we were strongly tempted to apply a sensible quantitative threshold condition. In other cases, it would have been possible to draw on expert knowledge in the team, for example, in respect of temperate natural ecosystems, to infer class attributes that were not stated explicitly in the published definitions. We tried to resist these temptations, for a number of reasons. For example, we had no means of testing the validity of any assumptions we might make without referring back to the way in which the system had been used to classify actual data. Furthermore, although we had detailed knowledge of certain ecosystems, there were many others with which we were unfamiliar. Recourse to external knowledge would have introduced an element of partiality, which would have distorted the analysis. We therefore limited our choice of attributes to those that were explicitly identified in the published definitions, even where this led to a very restricted set of attributes and, consequently, to a rather poor representation of the classes concerned.

A related issue concerns the treatment of *indicative* information. It is common practice to include in definitions features, such as plant species, which are characteristic of the class. An example might be '*Montane Raised Bog: ....often covered with sedges or evergreen dwarf shrubs....*'. Such information, while helpful for visualising the class, is not diagnostic. The rule of thumb we adopted was to *ask 'If this feature is absent, could the class rules be satisfied, nevertheless?'* If the answer to this question was 'Yes', then it would have been mistaken to include the feature as a *definitive* class attribute.

5.8.2. Boundary Conditions

Given clearly-defined classes, based on a common set of attributes, the correspondence between classifications can be estimated consistently and with high levels of confidence. However, differences in class boundary conditions between classifications mean that is rare for identical classes to exist in different systems. Commonly, there is overlap between classes, but this overlap is less than 100%. Moreover, a given land cover in one system will generally fall into more than one class in a second system, so that many-to-many relationships frequently apply between land classes in different schemes. An example from the present study serves to illustrate the issue. Two of the classification schemes considered in this study identified forest types on the basis of a broadly similar attribute set (see Table 2).

Table 2 Attributes used to record Evergreen Forest in two Land Cover Classifications

Category	Seasonality	Leaf Shape	Dominant Floristics	Canopy Height	Canopy Cover
Cambodia Land Cover Atlas - Evergreen Forest	Evergreen			>7m	>10%
Cambodia Land Cover Atlas - Coniferous Forest	Evergreen		Conifers	> 7m	> 10%
IGBP-DIS Global Land Cover - Evergreen Needle-leaf Forests	Evergreen	Needle-leaved		>2m	>60%
IGBP-DIS Global Land Cover - Evergreen Broadleaf Forests	Evergreen	Broad-leaved		>2m	>60%

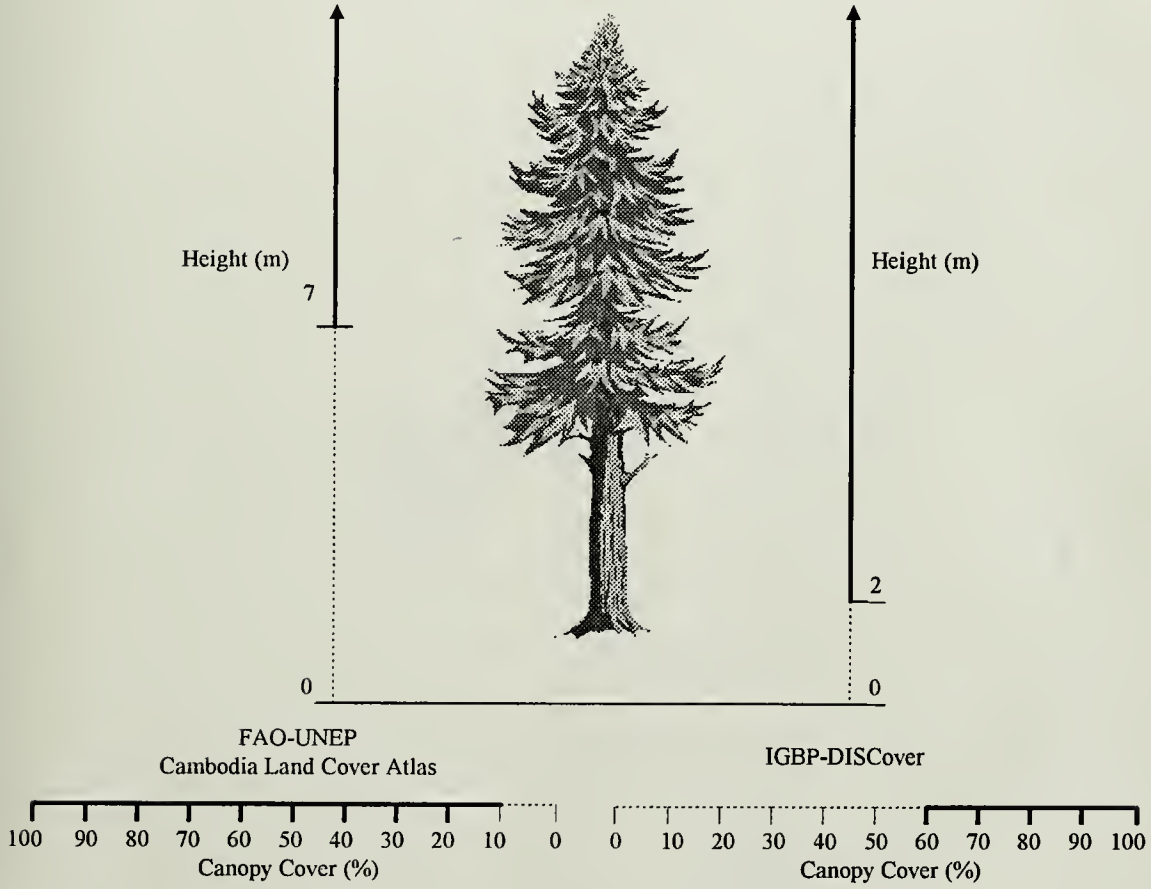
Key criteria adopted in these classifications are:

- the canopy height threshold used to distinguish between high forest and shrub;
- the minimum canopy percentage cover that distinguishes forest from other tree-dominated cover types.

Figure 21 shows the differences in the application of these two criteria between:

- the classification scheme used by the FAO-UNEP Land Cover Atlas of Cambodia;
- the land cover classification adopted for the IGBP-DIS Global 1km Land Cover Database.

Figure 21 Classification of Tropical Forest Types



Land is classified as '*Forest*' in both systems only when canopy height exceeds 7m and canopy cover 60%. Areas of woody vegetation between 2m and 7m in height are classified as '*Forest*' in the IGBP system, but not in the Cambodia Atlas. Conversely, the FAO-UNEP Atlas '*Forest*' class includes land with tree cover from 10 - 60%, that are described as '*Savannah*' by IGBP.

The actual situation is even more complex, since 5 attributes are employed in the two systems to distinguish the main evergreen forest types recognised (see Table 2). The FAO-UNEP Cambodian Land Cover Atlas divides evergreen forest into two main sub-types, based on the dominance, or otherwise, of coniferous species. The IGBP-DIS system likewise includes two evergreen forest classes, but, in this case, they are differentiated on the basis of the leaf shape of dominant tree species (Needle-leaved *vs.* Broad-leaved).

To represent the FAO-UNEP class '*Evergreen Forest*' in the IGBP-DIS system, two classes are needed - '*Evergreen Needle-leaved*' and '*Evergreen Broad-leaved*'. But, because of differences in threshold conditions of the other attributes (canopy height and proportional cover), overlap between these classes which purport to be similar, may, in fact, be quite small (Figure 22); in particular, the IGBP forest class will overlap with FAO-UNEP shrub classes, while less dense examples of the FAO-UNEP forest classes will correspond with IGBP savannah categories.

Figure 22a Correspondence between FAO-UNEP Cambodian Atlas Class '*Evergreen Forest*' and IGBP Class '*Evergreen Broad-leaved Forest*'

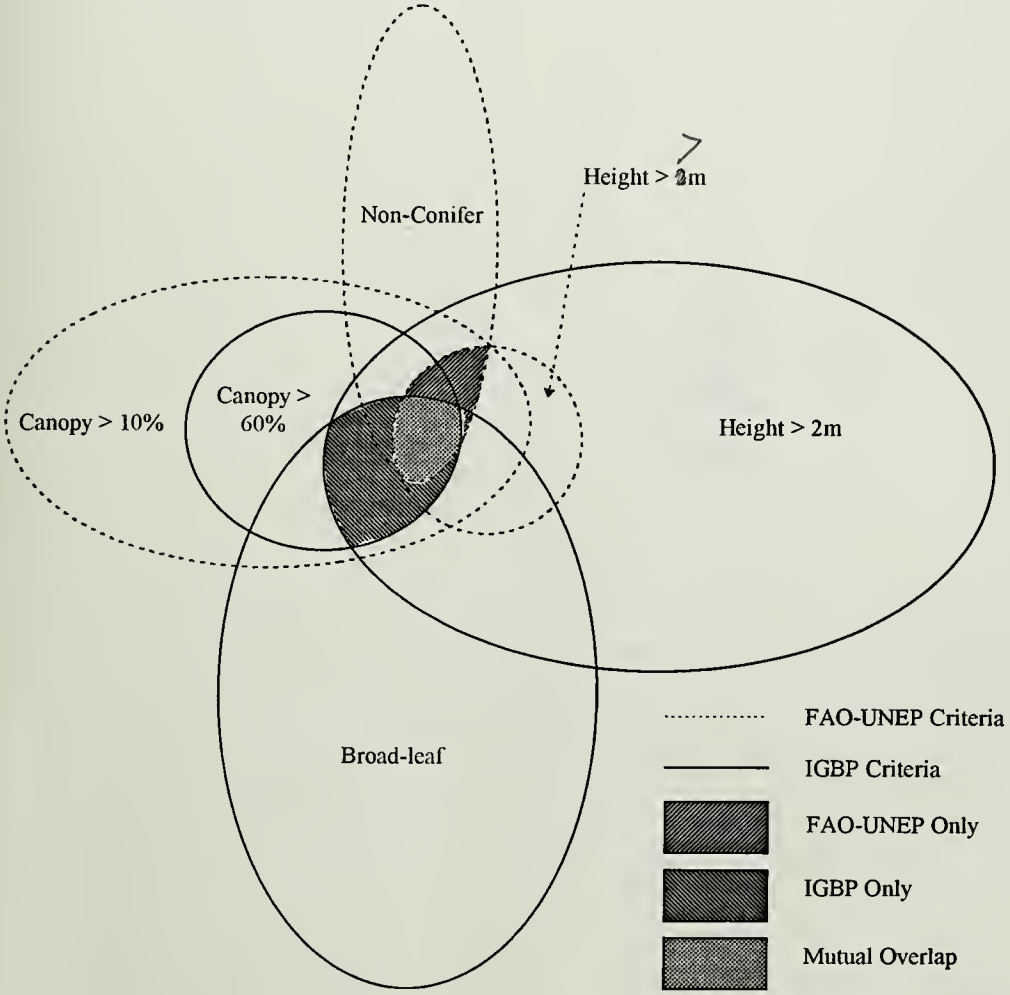
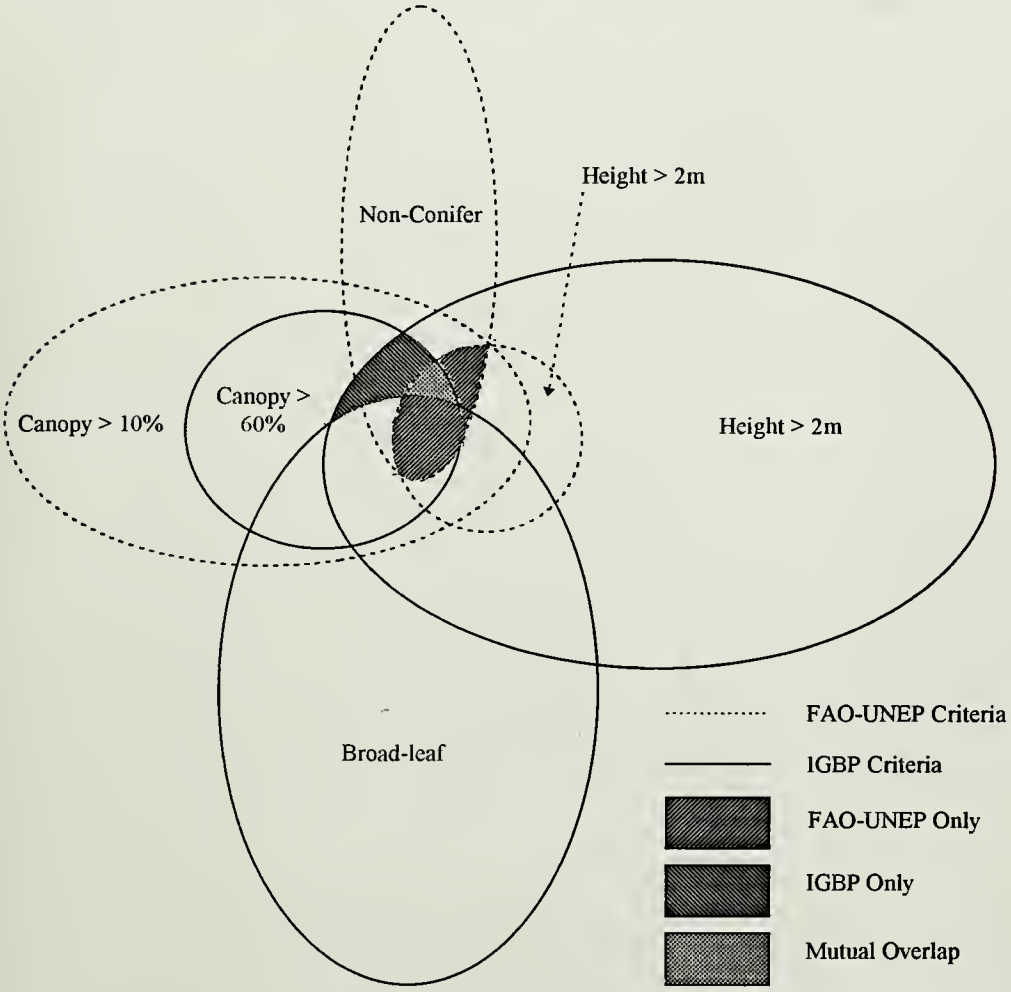


Figure 22b Correspondence between FAO-UNEP Cambodian Atlas Class '*Evergreen Forest*' and IGBP Class '*Evergreen Needle-leaved Forest*'



From this discussion, we conclude that, in principle, it is possible, by matching key attributes of land classes in different classifications, to make *qualitative* predictions about the overlap (or potential overlap) between the classes. We have seen that class thresholds, or boundary conditions, frequently differ between classifications; consequently, translation between systems (for example, to compare estimates of land cover recorded at different times using different classifications) cannot normally be achieved without reference to the manner in which the classifications were applied to actual data. In the earlier study in the UK (Wyatt *et al.*, 1994), land cover data from two contemporary surveys were used to inter-calibrate the classifications in this way.

5.8.3. Differences in Attributes

The above discussion assumes that a common set of attributes distinguish the classes to be compared: i.e. that class differences are primarily due to differences in boundary conditions. In the case of land use systems, this is a reasonable assumption. The key attributes of land use employed in this study (land use operations, intended products / benefits, species / services

involved) are increasingly recognised as providing a common basis for distinguishing land use classes. We found it comparatively straightforward to describe land use classes on the basis of these attributes of land use, and the results of the correlation exercise presented in Annex 5 are encouraging.

For land cover, there is presently no comparably uniform approach. In practice, systems often define equivalent classes in terms of different attributes. In the previous example, one system classified evergreen forest on floristic criteria, while the second made its primary subdivision on the basis of leaf shape. Such differences in the choice of attributes used to characterise cover classes will inevitably have a detrimental effect on the results of correlation. The most likely consequence is that recall will be reduced - i.e. that the correlation will fail to identify legitimate overlap between classes because the classes were defined in terms of quite different properties. **The only effective means of addressing this difficulty is to move towards the adoption of a commonly agreed set of land cover attributes and, in Section 6, we propose a basis to achieve this objective.**

5.9. Features of the Prototype System that may Influence Correlation

5.9.1. Modular design of the System

The Land Use - Land Cover Database handles land use and land cover attributes as two distinct modules (see Figure 5). This approach has the advantage of clarity: it avoids the trap of trying to describe land cover in terms of land use, and *vice versa*. However, as presently implemented, it is not possible to run searches which combine both aspects. Consequently, *a priori* classes that include elements of both cover and use cannot be fully represented by one system alone. Correlations can be investigated separately for each aspect, as in Annexes 5 and 6, but the results are misleading, since mixed use-cover classes which appear to overlap when only one aspect is considered, are quite distinct when both land use and land cover properties are taken into account.

For example, considering only land **cover** characteristics, CORINE class 1.4.2 (*Sport & Leisure Facilities*), which corresponds to areas of urban grass used for recreation, is equivalent to permanently-grassed agricultural and natural areas, such as grassland classes V.A, V.B. and V.C in the UNESCO Vegetation Classification, '*Herbaceous Steppes*' in the Classification of Range and Forest Resources of Senegal, or class 140 '*Agricultural Land - Grass Crops*' in the land cover classification of the Asian Association on Remote Sensing (see Annex 6).

In terms of land **use**, the same CORINE class corresponds to EUROSTAT CLUSTERS class A502 ('*Sports Facilities*') and to class 7.2 ('*Outdoor Recreation*') in the UK Land Use Stock System, both of which include also non-vegetated areas, such as all-weather sports grounds.

Ideally, it should be possible to match a priori classes simultaneously in terms of both land use and land cover attributes; when other planned ecosystem module, such as soil and climate have been implemented, these should also be accessible from a common query package.

5.9.2. Design of Glossaries

Glossaries control the terminology available to identify attributes of land use and land cover in the database (see Section 4.5). The hierarchical structure of these glossaries permits classes to be defined at varying levels of detail. For example, the physiognomy of herbaceous vegetation may be described at the generic level (e.g. '*Non-woody plants*'), or, if known, by the dominant physiognomic sub-type (e.g. '*Graminoids*', '*Forbs*'). Graminoids may be further subdivided, for example:

Tufted grasses
Tussock grasses
Sedges
Reeds

The query system exploits this hierarchical structure: for example, a search on '*Graminoids*' will retrieve classes that contain the attribute 'Plant Physiology - *Graminoids*' and also classes described using the more specific terms ('*Tufted grasses*', '*Sedges*', '*Reeds*', etc). It follows that the hierarchical design of the glossary trees has a strong influence upon retrieval performance.

This is especially true in the case of the land cover glossary tree '*Vegetation Characteristics*', which contains the terminology needed to express the rules which determine the boundary conditions of land cover classes. The glossary tree contains terms which describe presence / absence, areal extent or proportional cover, or properties (e.g. height, morphology, seasonality or composition) of the characteristic vegetation. There is an implicit hierarchy in many of these properties. In particular, if a cover type is 'dominant', or 'abundant', then, by definition, it must be 'present'. Currently, this hierarchy is not reflected in the glossary structure; there are separate sub-trees concerned with proportional cover, with frequency and with presence / absence. Consequently, a class defined as one where shrubs are **dominant** is not retrieved by a search which specifies only the **presence** of shrubs. At present, this is a major cause of recall errors when correlating classes by land cover, and some re-design of the structure of the glossary trees is clearly needed.

The glossary includes a number of different scales, or ranges associated with, for example, proportional cover, frequency, height; examples are the Braun-Blanquet and the Hult-Sernander cover scales, or the Braun-Blanquet and the Hanson scales of abundance. There is no mechanism, either within the glossary itself, or in the retrieval system, to inter-relate these different scales. Let us take the example of two similar classes defined as follows:

Class A
Subset = Trees
Rule = Cover, Braun-Blanquet Cover Scale 5

Class B
Subset = Trees
Rule = Cover, Hult-Sernander Cover Scale 5

The Braun-Blanquet Cover Scale 5 corresponds to proportional cover from 75 - 100%, while Hult-Sernander is from 50 - 100%, so that Class B **includes** Class A. At present, there is no mechanism by which the system can infer this relationship. Similarly, if a class is given a specific quantitative value, there is no means of correlating it with one that has been described in terms of any of the above scales.

Certain glossary terms are either, on the one hand, equivalent or, on the other, mutually exclusive. For example, bare land can be coded as:

Subset = Earth Surface: Un-vegetated
Rule = Present

or

Subset = Physiognomic Plant Group: Vegetated
Rule = Absent

In the present program, either notation is permissible, but the retrieval system is incapable of recognising their equivalence. Some additional intelligence needs to be introduced into the database in order to recognise that these statements are logically identical.

5.9.3. Design of the Query System

The present Query Module does not reproduce fully the subtlety and flexibility of the land cover data model. This model allows land units to be described in terms of one or more land cover sub-sets, each of which is characterised by a definition which identifies the subset and the boundary conditions. (For example, Subset = Bare Soil, Rule = Cover > 50%).

In the query module, there is no means of constraining Boolean expressions so that a given rule is linked to a single sub-set. The following example may help to explain the problem. In the USGS map of Rangelands in Senegal, Savannah woodlands are defined as follows:

Savannah Woodlands
- Definition
  - Subset : Graminoids
  - Rule : Quantitative height is smaller than or equal to 80.00 cm
- Definition
  - Subset : Forbs
  - Rule : Quantitative height is smaller than 80.00 cm
- Definition
  - Subset : Shrubs
  - Rule : Quantitative height is smaller than or equal to 5.00 m
- Definition
  - Subset : Trees
  - Rule : Quantitative height is larger than or equal to 5.00 m
- Definition
  - Subset : Canopy AND Trees
  - Rule : Cover percentage is between 20.00 - 50.00 % of Area

Formally, this requires the presence of:

Graminoids, less than or equal to 0.8m in height
AND
Forbs, less than 0.8m in height
AND
Shrubs, less than or equal to 5m in height
AND
Trees, greater than, or equal to 5m in height
AND
Tree canopy between 20 and 50% of area.

It is impossible to reproduce this search logic in the present system. An expression such as:

Graminoids
AND
≤ 0.8m in height
AND
...
Trees
AND
≥ 5m in height
....

clearly introduces logical conditions that cannot be satisfied (≤ 0.8m in height AND ≥ 5m in height). As a consequence of the mis-match between the sophistication of the data model and the crudeness of the search language, the complex queries needed to represent some land cover classes are likely both to generate false matches and to miss valid ones.

On a more practical note, there is presently no means of automatically generating a query from a class description. Instead, the query must be constructed manually, after inspecting the coded description of the class of interest. This is extremely time-consuming, and must be rectified if the system is to be put to operational use.

5.9.4. Differences in Interpretation

The land cover data model is an extremely flexible and sophisticated tool for recording characteristic properties of land cover. One consequence of this flexibility is that it is possible to describe the same land cover in several ways. One example, already cited is the ability to describe un-vegetated surfaces either in terms of the presence of bare substrate or in terms of the absence of vegetation. More significantly, different sub-sets may be selected by different operators to describe the same land cover unit. For example, in our analysis, evergreen forest was recorded on two separate occasions as follows:

Evergreen Forest (Cambodia Land Cover Atlas)
- Definition
  - Subset: Trees AND Evergreen
  - Rule: Height > 5m
- Definition
  - Subset: Trees AND Canopy
  - Rule: Cover > 80%

Evergreen Forest (Range & Forest Resources of Senegal)
- Definition
  - Subset: Trees AND Canopy
  - Rule: Cover > 10%
    Height > 7m
- Definition
  - Subset: Trees AND Evergreen
  - Rule: Cover > 80%

In the first case, the height threshold is applied to individual objects present in the land class (trees); in the second, the height attribute is applied to the tree canopy as a whole. This

difference may reflect real differences in the published definitions associated with the two classifications. Equally, it may be a consequence of different operator practice.

One difference in implementation that was noticeable was in the degree of detail of class descriptions each operator chose to encode. Some operators included considerable qualitative information (e.g. Graminoids, Height>0.8 m, Age = Mature..... Trees, Height > 8 m, Size = Large). The problem in this approach is that it becomes increasingly unlikely that these highly detailed definitions will match with any other at the retrieval stage.

It was not possible to conduct objective tests of the consistency with which the cover coding was applied. Random inspection of the descriptions held in the database indicates that it was not a major influence on the results obtained, and that differences in the class definitions themselves were far more significant. Nevertheless, in the interests of consistency, it would be useful to draw up more prescriptive rules of precedence for the way in which the system should be used to record land cover units, especially where their definitions are complex.

6. CLASSIFICATION

6.1. The need for reference classifications and the possibility of numerous special purpose classifications.

6.2. Approaches to classification (possible use of structure, life form, taxonomic features in that order)

6.3. Recommended reference classifications (use and cover).

6.4. Guide to assist users in classifying (key, possibly as an appendix)

7. PRACTICAL APPLICATION

7.1. Identification of appropriate attributes

7.2. Adaptation to data gathering methodology

7.3. Use in the Africover project

(Sims)

Understanding the relationships within and between different classifications requires lengthy, methodical processing. In addition, any kind of software development requires many months, if not years, before a robust, bug-free program is available. The Africover project requires such software within a matter of a few months. Therefore, in order to save time and money, and to as far as possible maintain a common approach, it is hoped to use the program currently under development as a basis for Africover, and if at all possible, to develop only one database, which will serve all purposes. It is therefore important that the requirements of the Africover project should be set out promptly, to the extent that they can now be foreseen.

8. FUTURE REQUIREMENTS

REFERENCES

Adamec, J. (1992). "Land use classification study". Consultant report, AGLS/FAO.

Anderson, J. R., Hardy, E. E., Roach, J. T. and Witmer, R.E. (1976). "A land use and land cover classification system for use with remote sensing." U.S. Geological Survey. 28 pp.

Commission of the European Communities, Directorate General for the Environment. (1992). "CORINE land cover - technical guide". Commission of the European Communities, Luxembourg.

de Bie, C.A., van Leeuwen, J.A. and Zuidema, P.A. (1996). "The Land Use Database. A knowledge-based software programme for structured storage and retrieval of user-defined land use data sets". Users' Reference Manual (v1.04, DOS). ITC, Enschede; FAO, Rome; Agricultural University, Wageningen.

De Wit, C.T., (1993). "Philosophy and terminology". In: P.A. Leffelaar (Ed.), "*On system analysis and simulation of ecological processes, with examples in CSMP and FORTRAN*". Kluwer Academic Publishers, Dordrecht, pp. 3-9.

Defries, R. S., and Townshend, J. R. G. (1994). "NDVI-derived land cover classifications at a global scale." *International Journal of Remote Sensing*, **15**(17), 3567-3586.

Duhamel, C. *et al.* (1995). "Classification for Land Use Statistics Eurostat Remote Sensing Programme (CLUSTERS)". Statistical Office of the European Communities.

Federal Geographic Data Committee (1995). FGDC Vegetation [Classification] Standards. Revised 31 July 1995 based upon 27 July Vegetation Sub Committee meeting. USA.

Food and Agricultural Organisation (1986). "Programme for the 1990 World Census of Agriculture". Food and Agriculture Organisation of the United Nations. Rome.

Food and Agricultural Organisation. (1990). "FAO-UNESCO soil map of the world: revised legend. Second edition. FAO, Rome.

Food and Agricultural Organisation. (1994). "Integrated Approach to the Planning and Management of Land Resources". Draft report of the UN Secretary-General on the Implementation of Chapter 10 of Agenda 21 (UNCED) to the Commission on Sustainable Development. Third Draft of Task Manager's Report. FAO/AGL, 28 November 1994, Rome. 30 pp.

Food and Agricultural Organisation - United Nations Environment Programme. (1994). "Cambodia - Land Cover Atlas, 1985/87 - 1992/93". Prepared by the Mekong Secretariat for Project CMB/92/93.

Fresco, L.O., Huizing, H., van Keulen, H., Luning, H. and Schipper, R. (1994). "Land evaluation and farming systems analysis for land use planning; LEFSA." FAO Guidelines: Working Document. FAO, Rome; ITC, Enschede; WAU, Wageningen.

Gierman, D.M. (1981). "Land use classification for land use monitoring". Working paper 17. Lands Directorate, Environment Canada.

IGBP-DIS (1996). "The IGBP-DIS global 1km land cover data set 'DISCover'. Proposal and implementation plans". Belward, A.S. (ed). Report of the Land Cover Working Group of IGBP-DIS. IGBP-DIS Working Paper 13. IGBP Data and Information System Office. Toulouse.

International Geographical Union. (1949). Report of the Commission to study the possibility of a "World Land Use Survey". International Geographical Union.

Land Cover Working Group of the Asian Association on Remote Sensing. (1995). "Draft classification".

Matthews, E. (1983). "Global vegetation and land use: new high-resolution data bases for climate studies." *Journal of Climate and Applied Meteorology*, **22**, 474-487.

Mücher, C.A. (1992). "A discussion on land use classifications". Agricultural University, Wageningen. FAO-commissioned study.

Mücher, C.A, Stomph, T.J, and Fresco, L.O. (1993). "Proposal for a global land use classification". FAO-commissioned study.

Olson, J. S., Watts, J., and Allison, L. (1983). "Carbon in live vegetation of major world ecosystems." *W-7405-ENG-26*, US Department of Energy, Oak Ridge National Laboratory.

Paijmans, K. (1975). "Vegetation of Papua New Guinea - Scale 1:1,000,000. Including Explanatory Notes to the Vegetation Map of Papua New Guinea". Land Research Series No. 35. Division of Land Use Research Commonwealth Scientific and Industrial Research Organization.

Remmerzwaal. A. (1989). "Classification of land and land use, first approach". Consultant report, AGLS/FAO.

Rodwell, J.S. (1991). "British plant communities." Cambridge University Press, Cambridge. 395 pp.

Sokal, R.R. (1974). "Classification: purposes, principles, progress, prospects". Science, **185**, 1115-1123

Stomph, T.J. and Fresco, L.O. (1991). "Procedures and database for the description and analysis of agricultural land use. A draft". FAO, Rome; ITC, Enschede; Wageningen Agricultural University. 76pp.

Townshend, J., Justice, C., Li, W., Gurney, C., and McManus, J. (1991). "Global land cover classification by remote sensing: present capabilities and future possibilities." *Remote Sensing of the Environment*, **35**, 243-255.

UN-ECE Statistical Division. (1993). "ECE standard statistical classification of land use". Readings in International Environmental Statistics. United Nations, New York. 1-5.

UNEP-FAO (1994). "Report of the UNEP/FAO Expert Meeting on Harmonising Land Cover and Land Use Classifications". Geneva 23-25, November 1993. GEMS Report Series No.25. UNEP, Nairobi.

UNEP-HEM (1993). "Report of the UNEP-HEM / WCMC / GCTE Preparatory Workshop on Vegetation Classification". Charlottesville, Virginia, USA, 24-26 January, 1993.

UNESCO (1973). *International classification and mapping of vegetation*. UNESCO, Paris.

United Kingdom Department of the Environment. (1996). "Land Use Information Base for England (National Land Use Stock System)". Planning and Land Use Statistics, Department of the Environment, London.

US Geological Survey, National Mapping Division, EROS Data Center. Range and Forest Resources of Senegal - Scale 1:1 million. Prepared for the US Agency for International Development.

Wilson, M. F., and Henderson-Sellers, A. (1985). "A global archive of land cover and soils data for use in general circulation climate models." *Journal of Climatology*, **5**, 119-143.

Wyatt, B. K., Greatorex-Davies, J. N., Hill, M. O., Parr, T. W., Bunce, R. G. H., and Fuller, R. M. (1994). "Comparison of land cover definitions." Countryside 1990 series, Department of the Environment, London.

Young, A (1994). "Towards International Classification Systems for Land Use and Land Cover". In: UNEP/FAO (1994). *Report of the UNEP/FAO Expert Meeting on Harmonising Land Cover and Land Use Classifications*. Geneva 23-25, November 1993. GEMS Report Series No.25. UNEP, Nairobi.

GLOSSARY

Classification
The ordering or arrangement of objects into groups or sets on the basis of their relationships.

Classification system
A logical framework, holding the names of the classes, the criteria used to distinguish them and the relationships between classes.

Classifier:
A diagnostic criterion used to define a class.

Identification:
The process of assigning additional new unidentified objects to the correct class.

Land:
Any delineable area of the earth's surface, involving all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), near-surface layers and associated ground water and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.).

Land classification system:
A structured collection of land class definitions

Land cover:
The observed physical cover, as seen on the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, etc.) which cover the earth's surface. Water, ice, bare rock or sand, and salt flats or similar un-vegetated surfaces also comprise land cover.

Land use:
A series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources.

Land use system:
A specific land use, practised during a known period on a known and contiguous area of land with reasonably uniform land characteristics.

Legend:
The application of a classification for a particular purpose, for example, for thematic mapping.

Reference Classification System:
A classification system designed to provide a framework for future use in collecting

ANNEX 1

STEERING GROUP FOR THE PROJECT 'HARMONIZATION OF NOMENCLATURE FOR RECORDING LAND USE AND LAND COVER GLOBALLY'

ANNEX 2

THE LAND USE GLOSSARY TREES

Classifiers: Context
Contains diagnostic criteria describing the land use context, which can be used to define *a-priori* land use classes, e.g. tenancy arrangement or capital intensity.

Classifiers: Operation Sequence
Contains diagnostic criteria describing the operation sequence or individual operations, which can be used to define *a-priori* land use classes, e.g. cultivation factor, cropping system, inputs used.

Gender & Age Classes
Contains classes by age for males and females that are used to specify the labour inputs as used during an operation, e.g. male adult (16-59 years) or child (<9 years).

Implement Origins
Contains sources from where (and how) the implements used to carry out operations and observations were obtained, e.g. rented, borrowed or owned.

Implements
Contains names of machines, tools, instruments, equipments and utensils, which are used to carry out an operation or observation. By definition, implements can be used more than once, in contrast to material inputs. The term implement does not refer to site-specific fixtures such as infrastructure. Examples of implements are hand tools and mechanical tools.

Infrastructures
Contains names of permanent installations constructed to assist economic activity, such as roads, irrigation or drainage works, buildings and communication systems. These installations may support the performance of a land use system.

Labour Origins
Contains the types and sources from where (and how) the labour used to carry out an operation, was obtained, e.g. land user's family.

Material Input Origins
Contains sources from where (and how) a material input used for an operation, was obtained, e.g. purchased from outside the holding, produce of another plot.

Material Inputs
Contains names of materials that may be used as input for an operation, e.g. seeds, organic manure, biocides. By definition, material inputs cannot be recovered after their use, whereas implements can leave the land use system after use.

Material Relocations
Contains sources and destinations (and relevant additional information) of materials that are added to or removed from the land use system, e.g. added to a stream, input by wind. Material relocations are related to observations on a land use system, not to land use operations.

Observation Names
Contains names of descriptions/measurements of a condition that may influence the performance of a land use system, that states its impact on the environment, or that reflects the indigenous knowledge of the land user about the land use system. Examples of observations are the Leaf Area Index (LAI) of the crop, or the occurrence of a grasshopper pest.

Operation Names
Contains names of distinct and intended management actions carried out by humans on land, e.g. harvesting, planting, collecting.

Power Sources
Contains sources of energy used to perform a land use operation, e.g. animal traction, solar energy.

Product Destination
Contains destinations (and relevant additional information) of products obtained from a land use system, e.g. sold to a trader, for own consumption.

Products/Benefits/Materials
Contains descriptions of products, benefits and materials that may be obtained from a land use system, e.g. grains, fodder, minerals.

Quality Classes
Contains classes to describe the quality of used implements, material inputs, products and benefits. Currently, this glossary tree does not contain well-defined classes, since these are often market-specific.

Skills
Contains levels of experience and expertise of labourers who carry out an operation, e.g. trainee, illiterate or experienced.

Species/services
Contains extensive lists of plants grown or animals held in a land use system, and functions of the land use system from which benefits are obtained, e.g. buckwheat, sheep, or recreation.

Tenancy Arrangements
Contains information on rights or arrangements under which the holder uses a parcel, e.g. owned, rented or traditional tenure.

ANNEX 3

BIBLIOGRAPHY OF GLOBAL LAND USE / LAND COVER CLASSIFICATIONS

Acock, J.P.H. (1953). Veld types of South Africa. *Memoirs of the Botanical Society of South Africa.* **28.**

Acock, J.P.H. (1975). Veld types of South Africa. *Memoirs of the Botanical Society of South Africa.* **40.**

Adamec, J. (1992). *Land use classification study.* AGLS, FAO, Rome.

Adams, J. (1992). Towards an improved vegetation classification scheme for global mapping and monitoring. *A background paper produced for the UNEP/HEM/WCMC/GCTE preparatory workshop Charlottesville, Virginia 24-26 January 1993.*

Anderson, J.R., Hardy, E.E. Roach, J.T & Witmer, R.E. (1976). *A land use and land cover classification system for use with remote sensing.* U.S. Geological Survey, 28 pp.

Anon (1993). Natural terrestrial cover classification: assumptions and definitions. Gap analysis technical bulletin 2. Source: Michael Jennings, US Fish & Wildlife Service, Idaho co-operative Fish and Wildlife Research Unit, University of Idaho, Moscow, ID 83843 USA.

Arbiol, R., Vines, O. & Camarasca, J.M. (1993). Land use mapping in Catalonia. *Proceedings of the Earsel/ESA symposium on Remote Sensing applications for environmental studies.* Series EASSP-188. Paris, France:ESA.

AUSLIG (nd). *Australia - Natural vegetation. 1:5 million.* Compiled by Botany Department, Australian National University, produced by Australian Surveying and Land Information Group, Department of Administrative Services.

AUSLIG (nd). *Australia - Present vegetation 1:5 million.* Compiled by botany department, Australian National University, produced by Australian Surveying and Land Information Group, Department of Administrative Services.

Bailey, R.G. (1989). *Eco-regions of the continents.* USDA Forest Service.

Bina, R.T. (1993). Examples of land cover and land use schemes in the Philippines. *Background paper for the UNEP/FAO expert meeting on harmonising land cover and land use classifications., Geneva.* Earthwatch, Global Environment Monitoring System. Nairobi March 1994.

BIRAS, (Botanical Institute Royal Academy of Sciences). (1990). *Vegetation of the USSR. 1:4 million scale.* Royal Academy of Sciences, Moscow.

Blasco, F. (1988). The International Vegetation Map. *Handbook of Vegetation Science.* Kluwer, Dordrecht, Netherlands.

Blasco, F. (1995). A Vegetation Map of Kenya - Scale 1:1 million. Institut de la Carte Internationale de la Vegetation, Toulouse, Universite Paul Sabatier, France.

Blasco, F. & Bellan, M.F. (1995). Vegetation maps and environmental conditions of: Tropical Continental Asia at 1:5,000,000. Laboratoire d'Ecologie Terrestre.

Bones, J.T. (1993). *Report for consultancy on forest definitions and classifications to be employed for Global Forest Resources Assessment, 2000.* FAO/ECE meeting of experts on Global Forest Resources Assessment - Kotka II, Finland, 3-7 May 1993. The Finnish Forest Research Institute, Helsinki, Finland.

Brown, D., Lowe, C. & Pace C. (1979). A digitised classification system for the biotic communities of North America, with community (series) and association examples for the Southwest. *Journal of the Arizona-Nevada Academy of Science.*, **14**: 1-16.

CEC, Directorate General for the Environment. (1992). *CORINE land cover - technical guide.* Commission of the European Communities, Luxembourg.

CEC/ESA (Commission of the European Communities / European Space Agency). (1991). Strategy proposal 1991-93, Part 1: AVHRR data collection and analysis. *Trees tropical ecosystem environment observations by satellites.* Trees series A: Technical document no. 1. CEC (Joint Research Centre, Institute for remote Sensing Applications) / ESA (ESRIN, Earthnet Programme Office).

CEC/ESA. (1994). Collection and pre-processing of NOAA-AVHRR 1 km resolution data for tropical forest resource assessment. *Trees tropical ecosystem environment observations by satellites.* Trees series A: Technical document no. 2. CEC (Joint Research Centre, IRSA) / ESA (ESRIN, Earthnet Programme Office).

China - Bureau of Agricultural Division etc. (1985). Guide book for land use investigation (Land Use classification system of China) Ed. by Bureau of Agricultural SDivision, National Planning Commission and Bureau of Land Management, Ministry of Agriculture, Pasture, and Fishery, Agriculture Press.

Collins, N.M., Sayer, J.A. & Whitmore, T.C. (eds). (1991). *The conservation atlas of tropical forests - Asia and the Pacific.* Macmillan Publishers Ltd., London.

Colpaert, A. Land use mapping with Landsat 5 TM imagery: a case study from Hailuato, Finland.

Correira, T.P. (1993). Threatened landscape in Alentejo, Portugal: The 'montado' and other 'agro-silvo-pastoral systems. In: Landscape and urban planning, **24,** 1/4, 43-48.

CRSSD (199?) Sri Lanka.

CWAA (Committee for the World Atlas of Agriculture) (Medici, G., Vanzetti, C., Anderson, J.R., Antonietti, A., Britton, D.K., Chatterjee, S.P., Chen, C.S., Edwards, K.C., George, P., Giggs, J.A., Klatzmann, J., Rauterberg, B., Saab, G.S., Troll, C., Valverde, O. & van Riemsdijk, J.F.). (1969). *World Atlas of Agriculture.* Under the aegis of the International Association of Agricultural Economists. Instituto Geographico De Agostini-Novara.

DCGT, DEPU, AUA, SCU. (Direction et Controle des Grands Travaux, Direction de Etudes et Projets Urbains, Atelier d'Urbanisme a'Abidjan, Service de Cartographie Urbaine). !989). *Abidjan carte des modes d'occupation des sols.*

de Bie, K. (1993). *Describing and classifying land use systems.* ITC, Enschede, Netherlands.

de Bie, K. and J. van Leeuwen (1994). *The land use database. Version 1.0, January 1994. Pre release. Computer diskette and user notes.* Enschede, ITC/FAO/WAU.

DeFries, R.S. & Townshend, J.R.G. (1994a). NDVI-derived land cover classifications at a global scale. *International Journal of Remote Sensing.* **15,** (17), 3567-3586.

DeFries, R.S. & Townshend, J.R.G. (1994b). *Environmental Remote Sensing from Regional to Global Scales.* Ed by Foody & Curran. John Wiley.

Delsol, J.P. (1995). Vegetation maps and environmental conditions of: Kenya at 1:1,000,000. Laboratoire d'Ecologie Terestre de Toulouse.

Devillers, P & Devillers-Terschuren, J. (1993). *A classification of Palaearctic habitats - a preliminary list of priority habitats in Council of Europe Member States.* A report to the Council of Europe. T-PVS (94)1.

Driscoll et al. (1984). An ecological land classification framework for the United States. US Dept. Agric. Misc. Pub. No. 1439. 56 p. (Can be purchased from: Superintendent of Documents, US Government Printing Office, Washington, DC 20402 USA).

Duhamel, C. (et al) (1995). Classification for Land Use Statistics Eurostat Remote Sensing Programme (CLUSTERS). Statistical Office of the European Communities.

ECE Statistical Division. (1993). ECE standard statistical classification of land use. *Readings in International Environmental Statistics.* United Nations, New York. 1-5.

Edwards, D. (1983). A broad-purpose structural classifiaction of vegetation for practical purposes. *Bothalia,* **14,** (3 & 4) 705-712.

Eiten, G. (1968). Vegetation forms. A classification of stands of vegetation based on structure, growth form of the components and vegetative periodicity. Bol. 4. *Inst Botanica*, Sao Paulo, Brazil, 88pp.

Environment Agency. (1982 etc). *1:50,000 scale Actual Vegetation Maps.* Tokyo. (In Japanese with English legend).

EWGCCELC, (Ecoregions Working Group Canada Committee on Ecological Land Classification). (1989). *Ecoclimatic regions of Canada - First approximation.* Minister of Supply and Services. Sustainable Development Branch, Canadian Wildlife Service Conservation and Protection, Environment Canada., Ottawa, Canada.

Eyre, S.R. (1968). *Vegetation and soils: A world picture.* 2nd edition. Edward Arnold, London. pp195-258.

FAO (1976). A framework for land evaluation. *Soil Bulletin*, Wageningen.

FAO (1986). *Programme for the 1990 world census of agriculture.* Food and Agriculture Organisation of the United Nations (FAO), Rome.

FAO (1989). *Classification and mapping of vegetation types in Tropical Asia.* FAO, Rome.

FAO (1993). *Forest resources assessment 1990: Tropical countries. Forestry Paper.* FAO, Rome.

FAO (1994). *Africover Project - Land cover map and data base of Africa based on satellite remote sensing. Report on the technical consultation and donor consultation on the AFRICOVER Project and annexes. ECA headquarters Addis Ababa 4-11-July 1994.* FAO, Rome.

FAO (1995). *Programme for the World Census of Agriculture 2000.* Food and Agriculture Organisation of the United Nations (FAO), Rome.

FAO/UNEP (1981a). *Los recursos forestales de la American.* FAO, Rome.

FAO/UNEP (1981b). *Forest Resources of Tropical Asia.* FAO, Rome.FGDC (1995). FGDC Vegetation [Classification] Standards. Revised 31 July 1995 based upon 27 July Vegetation Sub Committee meeting. USA.

FAO/UNEP (1981c). *Forest resources of Tropical Africa, Part 1 & 2.* FAO, Rome.

FAO/UNEP (1994). *Cambodia - Land Cover Atlas, 1985/87 - 1992/93.* Prepared by the Mekong Secretariat for Project CMB/92/93.

Federal Statistical Office. (19--). National Land Use classification. Federal Statistical Office, Federal Republic of Germany, (Contact Michael Deggau).

FGDC (1995). FGDC Vegetation [Classification] Standards. Revised 31 July 1995 based upon 27 July Vegetation Sub Committee meeting. USA.

Fontes, J. (1995). Vegetation maps and environmental conditions of: Burkina Faso (West Africa) at 1:1,000,000. Laboratoire d'Ecologie Terestre de Toulouse.

Fosberg, F.R. (1961). A classification of vegetation for general purposes. *Tropical Ecology*, 2: 1-28.

Fosberg, F.R. (1967). A classification of vegetation for general purposes. *Guide to the checksheet for IBP areas. IBP Handbook No 4.* Blackwell, Oxford.

Fraser. (1958). Landforms, soils and land use of the Indus Plains, West Pakistan. A Colombo Plan Cooperative Project, Ministry of Food and Agriculture, Government of Pakistan, Islamabad.

Fuller, R.M., Groom, G.B. Jones, A.R. & THompson A.G. (1993). *Countryside Survey 1990: Mapping the land cover of Britain using Landsat imagery: a demonstrator project in remote sensing. (Final report to the British National Space Centre).* Institute of Terrestrial Ecology, Abbots Ripton, U.K.

Garitty, D & Augustin, F. (1995). Land use change in Mindanoa, Philippines. *Agriculture, Ecosystems and Environment*, March 1995.

Geographical Survey Institute. (1977). *The National Atlas of Japan.* The Japan Map Centre, Tokyo. (In English).

Geographical Survey Institute. (Constantly updated). *1:25,000 and 1: 50,000 scale Land Use Maps. Tsukuba.* (In Japanese).

Geographical Survey Institute. (1995). *Global Map, Vegetation Index Pilot data in and around Japan (CD-ROM).* Tsukuba. (In English).

Geographical Survey Institute. (1974-). *National Land Digital Information, Land Use (1km grid, MT).* Tsukuba. (In Japanese).

Geographical Survey Institute. (Constantly updated). *Digital Map Information, Land Use files (100m grid, FD).* Tsukuba. (In Japanese).

Gierman, D.M. (1981). *Land use classification for land use monitoring. Working paper 17.* Lands Directorate, Environment Canada.

Gils, H. van, Huizing, H., Kannegieter, A. & Zee, D. van de. (1993). The evolution of the ITC system of rural land use and land cover classification (LUCC). *ITC Journal*, **3**: 163-167

Government of Indonesia/ODNRI. (1990). *The land resources of Indonesia - a national overview atlas.*

Goward, S.N., Tucker, C.J. & Dye D.G. (1985). North American vegetation patterns observed with the NOAA-7 advanced very high resolution radiometer. *Vegetatio*, **64**: 3-14.

Hamazaki, T. & Micosa A.G. (1991). Land Capability Classification in Japan - Productive Capability Classification of land based on soil survey. *Res. Rep. Div. Environ. Planning. NIAES*, 7, 1-20. Tsukuba. (In English

Harcourt, C.S. & Sayer, J.A. (eds). (199 ?). *The conservation atlas of tropical forests - the Americas.* Simon and Schuster, New York.

Holdridge, L.R. (1967). *Life zone ecology.* Tropical Science Centre, San Jose.

Howard, J.A. & Schade, J. (1982). *Towards a standardised hierarchical classification of vegetation for remote sensing.* FAO, Rome.

Hueck, K. (1972). *Mapa de la vegetacion de America del sur. 1:8,000,000* Gustav Fischer Verlag Stuttgart.

IBGE. (1993). *Mapa de VegetaH@o do Brazil.* IBGE, Rio de Janeiro.

IGBP-DIS LCWG (International Geosphere-Biosphere Programme - Data Information Systems Land Cover Working Group). (1994). *Draft IGBP-DIS LCWG global land cover classification.*

IGN France. (1994). *Recherches methodologiques sur l'utilisation de la teledetection spatiale en amenagement urbain.*

IGU (International Geographic Union). (1976). World land use survey. Report of the commission to the General Assembly of the IGU. *Geographica Helvetica* **31, (1).**

Ihse, M. (1978). *Aerial photo interpretation of vegetation in South and Central Sweden: A methodological study of medium scale mapping (summary).* Statens Naturvardsverk. pp. 142-149.

IIASA (International Institute for Applied Systems Analysis). (1994). Modelling Land Use and Land Cover changes in Europe and Northern Asia. Excerpts from IIASA 1995 Research Plan. Laxenburg, Austria.

Indonesian Directorate of land use. (1983). Land use classification. Directorate of land use, General Directorate or Agraria Department of the Interior, Indonesia

INEGI (National Institute of Statistics, Geography and Informatics). (1994). Mexico land use and vegetation classification for 1:250,000 and 1:1million scales. Prepared by INEGI with assistance from Environment Canada.

Instituto Geographicao A. Codazzi. (1963). *Formaciones de vegetatio de Columbia.* Bogota.

IRSA (1992). *Nomenclature for ground survey (extension of CRONOS codes).* Institute of Remote Sensing, Joint Research Centre, Commission of the European Communities, Ispra. (Internal document).

ITC (1993). *Major land use types. Production attributes. Computer listings, March 1993.* ITC, Enschede, Netherlands.

IUCN (1973). *A working system for classification of world vegetation prepared by the IUCN Secretariat with the guidance of the IUCN Commission on Ecology.* IUCN ?, Morges, Switzerland.

IUCN (1990). *United Nations list of National Parks and protected areas.* IUCN, Cambridge, UK.

IUFRO (1992). *IUFRO international guidelines for forest monitoring 15 November 1992. Draft. International Union of Forestry Research Organisations, Subject Group S.4.02.00 Forest Resource Inventory and Monitoring.* Unpublished.

James, et al. (nd). Types of natural vegetation. *The Times Atlas of the World.* Time Books in collaboration with Bartholomew & Son Ltd.

Jankowski, W. (1982). Polish experiences in land use mapping. *Geographica-Polonica,* **48,** 59-69.

Japan Details of land use maps - Japan.

Justice, C.O. & Kendall, J.D. Assessment of the forests of Central Africa using coarse resolution satellite data.

Koomanoff, V.A. (1989). *Analysis of global vegetation patterns: a comparison between remotely sensed data and a conventional map. Biogeography Research Series.* Department of Geography, University of Maryland, College Park.

Kostrowicki, J. (1983). Land use survey, agricultural typology and land use systems: introductory remarks. *Rural Systems,* **1** (1): 1-24

Kuchler, A.W. (1949). A physiognomic classification of vegetation. *Ann. Ass. Am. Geog.,* **39** (3): 201-210

Kuchler, A.W. (1967). *Vegetation mapping.* Ronald Press, New York.

Kuchler, A.W. & Zonnerveld (1988). *Vegetation mapping: Handbook of vegetation science 10.* Kluwer, Dordrecht, Netherlands.

Kuhnholtz-Lordat. (1949). *La cartographie parcellaire de la vegetation.* IRNA ed.

Lavenu, F. (1987). *Vegetation map of Africa.* Institut de la Carte Internationale de la Vegetation Universite Paul Sabatier. Prepared for the Department of Forest Resources, FAO, Rome. Toulouse Cedex, France.

LCWG of the AARS (Land Cover Working Group of the Asian Association on Remote Sensing. (1995). Draft classification.

Legris, P. and Blasco F. (1972). Carte International du tapis vegetal a 1:1,000,000, Cambodge. Note explicative. *Inst. Fr. Pondichery, Trav. Sect. Scient. Tech,* **11**: 240 pp.

Lloyd, D. (1990). A phenological classification of terrestrial vegetation cover using short -wave Vegetation Index Imagery. *International Journal of Remote Sensing,* **11** (12): 2269-2279.

Loveland, T., Merchant, J. Ohlen, D. & Brown, J. (1991). Development of a land cover characteristics database for the conterminous US. *Photogrammetric Engineering & Remote Sensing,* 57: 1453-1463.

Lowe, J.J., Power, K. & Gray, S.L. (1994). *Canada's Forest Inventory 1991.*

Malaysia (-?-). Land Use Classification.

Matthews, E. (1983). Global vegetation and land use: new high resolution data bases for climate studies. *Journal of Climate and Applied Meteorology,* **22**: 474-487.

Millington, A.C. et al. (1994). *Estimating woody biomass in sub-Saharan Africa.* Report prepared by ETC International for the World Bank.

Ministry of Agriculture, Bhutan. (1994). *Sustainable land use, guidelines for Bhutan, guideliens on land use and land cover classification.*

MSU (1986). *Land-use of the world. 1:15 million scale.* Moscow State University, Moscow.

MSU (1993). *World map of present-day landscapes (geosystems). 1:15 million scale.* Moscow State University, Moscow.

Mueller-Dombois, D. & Ellenberg, H. (1974). *Aims and methods of vegetation ecology.* Wiley, New York. 547pp.

Mucher, C.A., Stomph, T.J. Fresco, L.O. (1993). *Proposal for a global land use system.* FAO Rome/ITC, Enschede/University of Wageningen.

National Land Agency. (1970-1979). *1:22,000 scale Land Classification Maps, Present Land Use Maps and Land Use Capability Classification Maps.* Tokyo. (In Japanese with English legend.

National Land Agency. (1959-). *1:50,000 scale Land Classification Maps, Land Use Maps.* Tokyo. (In Japanese with English legend).

Nature Conservancy (USA). (1994). Standard National Vegetation Classification System (final draft). Prepared for the USDI National Biological Survey and National Park Service by the Nature Conservancy (1815 N. Lynn Street, Arlington, VA 22209 USA.

O'Donovan, G., Tempany, K. & O'Sullivan, G. (1993). Grasslands from the sky - the CORINE land cover project in Ireland. In: *Forward with grass into Europe.* Proceedings of the British Grassland Society. Winter meeting, Great Malvern, Worcestershire, England, November 1992.

Olson, D.M. & E. Dinnerstein *Vegetation classification for the whole of Tropical Africa.*

Olson, J.S. and Watts, J.A. (1982). Major World Ecosystem Complexes - Ranked by carbon in live vegetation. Prepared for the Carbon Dioxide Research Division of the United States Department of Energy and the Ecosystem Studies Program of the National Science Foundation, by Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. AND accompanying report:

Olson, J.S., Watts, J.A. & Allison, L.J. (1982). Carbon in Live Vegetation of Major World Ecosystems. Report ORNL-5862 - Environmental Sciences Division Publication No. 1997. Oak Ridge National Laboratory, Oak Ridge, TN 37830, USA.

Paijmans, K. (1975). Vegetation of Papua New Guinea - Scale 1:1,000,000. Including Explanatory Notes to the Vegetation Map of Papua New Guinea. Land Research Series No. 35. Division of Land Use Research Commonwealth Scientific and Industrial Research Organization.

PFI. (Pakistan Forest Institute). (1965). Peshwar.

PFI. (Pakistan Forest Institute). (1984). Range Department, PFI, Peshwar.

PFI. (Pakistan Forest Institute). (1987). (Productive and protective forest areas by forest type). Pakistan Forest Institute.

Pratt, D.J., Greenway, P.J. & Gwynne, M.D. (1966). A classification of East African rangeland, with an appendix on terminology. *Journal of Appied Ecology.* **3,** 369-382.

Quintanilla, V. (1995). Vegetation maps and environmental conditions of: Chile: Coastal temperate forests of Chile at 1:500,000. Laboratoire d'Ecologie Terestre de Toulouse.

RADAMBRAZIL. (1973-). (1:1,000,000 natural vegetation maps covering much of northern Brazil - also land use). Ministerio das Minas e energia, Departmento Nacional da Producao Mineral. Rio de Janiero, Brazil.

Remmelzwaal, A. (1989). *Classification of land and land use, first approach, April 1989.* AGLS, FAO, Rome.

Rivard L., Turner, A.M., Ryerson, R.A. & Vincent, P. (1990). Land Use mapping with Thematic Mapper Imagery: A Canadian perspective. *Geocarto International*, **1,** 33-50. (Includes a classification, in French, for Cameroun, West Africa).

Running, S.W., Loveland, T.R. & Pierce, L.L. (1994). A vegetation classification logic based on remote sensing for use in global scale biogeochemical models. *Ambio*, **23,** 77-81.

Sayer, J.A., Harcourt, C.S. & Collins, N.M. (eds). (1992). *The conservation atlas of tropical forests - Africa.* Macmillan Publishers Ltd., London.

Schultink, G. (1992). Integrated remote sensing, spatial information systems, and applied models in resource development, and policy analysis. *Photogrammetric Engineering & Remote Sensing*, **8,** 1229-1237. (Includes a land cover / use classification for Haiti).

Sharma, M.K. (1986). *Ecofloristic zone and vegetation maps of Tropical Continental Asia.* Institut de la Carte de la Vegetation Universite Paul Sabatier, Toulouse, France.

Sharma, M.K. (1986). *A vegetation map of Tropical Continental Asia on 1:5 million scale.* Institut de la Carte de la Vegetation Universite Paul Sabatier, Toulouse, France.

Sharma, M.K. (1988). *Ecofloristic zone map of Africa.* Institut de la Carte de la Vegetation Universite Paul Sabatier, Toulouse, France.

Shishi-Kant, Kant S. (1992). Digital mapping of vegetation cover using Landsat data. *Journal of Tropical Forestry*, **8,** 51-54. (An assessment was made of the suitability of Landsat MSS data for vegetation and land use classification in the Doon Valley, Uttar Predesh).

Sims, D. (1992). *A common classification of land use.* AGLS, FAO, Rome.

Sims, D. (1993). *Definition of land use types and production systems in relation to the AD 2000 agricultural census.* FAO, Rome.

Sombroek, W.G. (1993). *Land uses arranged in degree of departure from natural land conditions and intensity of use (labour, capital). Second draft, October 1993. Internal document.* AGLS, FAO., Rome.

Soyuzkarta. (1993). *World map of present day landscapes.*

SSP. (1963). Soil survey of Pakistan. Lahore.

Stewart, M. (1987). A guide to the mapping of forest and land use types in the Koshi Hills, Eastern Nepal. Overseas Development Administraion. Land Resources Development Centre, England.

Stomph, T.J. & Fresco, L.O. (1991). *Procedures and database for the description and analysis of agricultural land use. A draft.* FAO Rome/ ITC, Enschede/ University of Wageningen.

Tamraker, R.M. (1986). Land Resource Mapping Project. Land Utilisation Report 1986. His Majesty's Government of Nepal & Government of Canada.

Tamraker, R.M., Jabegu, K. & Shrestha, B. (1991). Land-use changes in the Jhikhu Khola watershed area 1972 - 1990. In:*Soil fertility and erosion issues in the middle mountains of Nepal.* Workshop Proceedings, Jhikhu Khola Watershed, April 22-25, 1991. Sponsored by IDRC (International Development Research Centre, Canada).

Tamraker, R.M. (1993). A comparative study of land use changes in the Shivapuri integrated watershed development area between 1981 - 1993. Ministry of Forest and Soil Conservation Department of Soil Conservation and Watershed Management. His Majesty's Government of Nepal. Food & Agriculture Organisation of the United Nations.

Tamraker, R.M. (1995). Annex 3: Land Use. In: Limits to growth: Kathmandu Valley (integrating environment and development). Kathmandu valley sustainable development policy and action plan. National Planning Commission, IUCN - The World Conservation Union, NCS Implementation Project, Technical Studies Programme.

Tateishi, R. & Kajiwara, K. (1991). Land cover monitoring in Asia by NOAA GVI data. *Geocarta International*, **6**, (4), 53-64.

TER.UTI. Nomenclatures physiques et fonctionnelles de l'enquLte TER.UTI. (FAO/ECE:ESS (93) - 18.)

Thailand. Land Use classification.

The Agency for Cultural Affairs, Ministry of Education. (1969-1983). *1:200,000 scale Vegetation Maps*. Tokyo. (In Japanese with English legend).

Thompson, M. (1994). *A standard land classification system for remote sensing applications in South Africa*. Draft version 1.1, Environment Information Technology Programme, Forestek, CSIR.

Townshend, J., Juctice, C., Li, W., Gurney, C. & McManns J. (1991). Global land cover classification by remote sensing: present and future possibilities. *Remote Sensing and Environment*, **35**, (2-3), 243-255.

Townshend, J.R.G., Justice, C.O. & Kalb, V.T. (1987). Characterisation and classification of South American land cover types using satellite data. *International Journal of Remote Sensing*, 8: 1189-1207.

Tucker, C.J., Townshend, J.R.G. & Goff, T.E. (1985). African land cover classification using satellite data. *Science*, **227**: 233-250.

Turner, B.L. II. (1990). *The earth as transformed by human action. Global and regional changes in the biosphere over the past 300 years*. Cambridge University Press.

Udvardy, M.D.F. (1975). *A classification of the biogeographical provinces of the world. Prepared as a contribution to Unesco's man and the biosphere programme Project No. 8. IUCN Occasional Paper No.18*. IUCN, Switzerland.

UN (1990). *International standard industrial classification of all economic activities, third revision*. United Nations, (Department of International Economic and Social Affairs, Statistical Office), New York.

UNDP/FAO (1994). *Cambodia Land Cover Atlas, 1985/87 - 1992/93*. (Including national and provincial statistics.Prepared by the Mekong Secretariat for project CMB/92/005.

UN-ECE/FAO (1990). *The forest resources of the temperate zones. I. General forest resources information. II. Benefits and functions of the forest*. United Nations, New York.

UN-ECE/FAO (1992). *The forest resources of the temperate zones. Main findings of the UN-ECE/FAO 1990 forest resources assessment. ECE/TIM/60*. United Nations, Geneva.

UNEP *World atlas of desertification*.

UNESCO (1973). *International classification and mapping of vegetation*. UNESCO, Paris.

UNESCO (1981). *Vegetation map of South America: explanatory notes*. UNESCO, Paris.

US-Geological-Survey (1986). *Land use and land cover digital data from 1:250,000 and 1:100,000 scale maps*. U.S. Geological Survey, Reston, Virginia.

US Geological Survey, National Mapping Division, EROS Data Center (nd). Range and Forest Resources of Senegal - Scale 1:1 million. Prepared for the US agency fr International Development. (Satellite data - post 1986)

VegRIS (1993). Vegetation Resources Information System. *ForMat* , Newsletter of the Research and Development Division, Zimbabwe Forestry Commission.

Vietnam Land use classification. Land Management General Directorate. (Simpler classification has since been proposed.

Walter, H. (1973). *Vegetation of the Earth*. Springer, New York.

WCMC (World Conservation Monitoring Centre). (1992). *Assessing the conservation status of the world's tropical forest*. WCMC, Cambridge, UK.

White, F. (1983). *The vegetation of Africa*. UNESCO, Paris.

Whitmore, T.C. (1984). Vegetation of Malesia - 1:5,000,000. Commonwealth Forestry Institute, Oxford University. A contribution to Global Environment Monitoring System, United Nations Environment Programme. *Journal of Biogeography*, **11**.

Wyatt, B.K., Greatorex-Davies, J.N., Hill, M.O., Parr, T.W. Bunce, R.H.G. & Fuller, R.M. (1994). *Countryside Survey 1990: Comparison of land cover definitions.* Department of the Environment, London.

Yasuoka, Y. (1993). Land use and land cover classificatin for environmental monitoring by using remote sensing - case studies in Japan. Prepared for the UNEP/FAO expert meeting on harmonizing land cover and land use classifications, Geneva, November 23-25 1993.

Yasuoka, Y., Yamagata, Y. & Tamura, M. (1993). Global mapping and monitoring of wetlands with satellite images - project proposal.

Young, A. (1994). Towards international classification systems for land use and land cover. *Report of the UNEP/FAO expert meeting on harmonising land cover and land use classifications - Geneva, 23-25 November 1993.* Earthwatch - Global environment Monitoring System.

Zhu, Zhiliang, & Evans, D.L. (1994). U.S. forest types and predicted percent forest cover from AVHRR data. *Photogramm. Engr. & Remote Sensing*, **60**, 525-531.

ANNEX 4 Characteristics of Land Classifications in Common Use

					Scale				Biome			Data coll'n.			Output		Application								
Author/Agency	Date	Land use	Land cover	Global	Continental	Regional	National	Sub-National	Tropics	Temperate	Polar	Remote Sensing/API	Ground Survey	Census	Mapping	Statistics	Vegetation	Agriculture	Forestry	Urban	Arid	Conservation	Biogeog/Biodiversity	Climate Change
Acock	1953		•				S Africa																	
Acock	1975		•				S Africa																	
Adamec	1992	•																						
Adams	1992		•	•											•		•							
Agency fo Cultural Affairs etc	1969-83		•				Japan			•			•		•		•							
Anderson et al	1976	•	•				USA					•												
Anon	1993		•				USA																	
AUSLIG	no date		•		Australia										•		•							
Bailey	1989		•	•											•	•								
Bina	1993	•	•				Philippines									•								
BIRAS	1990		•			USSR											•							
Blasco	1988		•	•								•	•		•		•							
Blasco	1995		•				Kenya		•						•		•							
Blasco & Bellan	1995		•		Asia				•								•							
Bones	1993		•	•															•					
Brown et al	1979		•		N America																			
CEC (CORINE)	1992		•		Europe																			
CEC/ESA (TREES)	1991	•		•					•			•							•					
China -Bureau etc	1985	•					China																	
Collins et al	1991		•		Asia/Pacif				•										•			•		
CRSSD - Sri Lanka	1989	•					Sn Lanka					•			•									
CWAA	1989		•	•											•			•						
DCGT, DEPU, AUA, SCU	1989		•				Ivory Coast	•							•					•				
De Bie (ITC)	1993	•		•																				
De Bie & van Leeuwen	1994	•		•																				
DeFries & Townshend	1994		•	•								•					•							
Delsol	1995		•				Kenya										•							
Devillers & Devillers-Terschuren	1993		•		Europe																	•		
Driscoll et al	1984		•				USA																	
Duhamel	1995	•				Europe						•				•				•				
ECE Std. Stat. Classification	1993	•			Europe											•								
Edwards	1983		•														•							
Eiten	1968		•		S America												•							
Environment Agency	1982 etc		•				Japan			•		•	•		•		•							
EWGCCELC	1989		•				Canada								•									
Eyre	1968		•	•													•							
FAO	1986	•		•										•		•		•						
FAO	1989		•		Asia				•						•		•							
FAO	1993								•										•					
FAO	1994		•		Africa							•			•									
FAO	1995?	•		•										•		•		•						
FAO/UNEP	1981a				America														•					
FAO/UNEP	1981b				Asia				•										•					
FAO/UNEP	1981c				Africa				•										•					
FAO/UNEP	1994		•				Cambodia								•									
Federal Stat. Office - Germany	19---	•					Germany									•								
FGDC	1995	•	•				USA										•							
Fontes	1995		•				Burkina Faso										•							
Fosberg	1961		•														•							
Fosberg	1967		•														•							
Fraser	1958	•					Pakistan																	
Fuller et al	1994		•				Great Britain					•			•									
Geographical Survey Institute	1974	•					Japan			•			•		•									
Geographical Survey Institute	1977	•	•				Japan			•			•		•		•							
GeographicalSurvey Institute	1995		•	•								•			•		•							
Geographical Survey Institute	Updated	•					Japan			•		•	•											
GeographicalSurvey Institute	Updated	•					Japan			•		•	•											
Gierman	1981	•					Canada	•							•	•		•	•	•		•		
Gils et al ITC-LUCC	1991	•	•	•								•			•									
Govt. of Indonesia	1990		•			Indonesia									•									
Goward et al	1985		•		N America							•					•							
Hamzaki & Micosa	1991	•					Japan			•			•					•							
Harcourt & Sayer	199 ?				Americas				•										•			•		
Holdridge	1967		•	•											•									•
Howard & Schade	1992		•	•								•					•							
Hueck	1972		•		S. America										•		•							
IBGE	1993		•				Brazil								•		•							
IGBP-DIS	1995		•	•								•												•
IGN France	1994		•																	•				
IGU	1976	•		•																				
Ihse	1978		•				Sweden					•			•		•							
Indonesia, Direct. of Land Use	1983	•				Indonesia																		
INEGI	1994	•	•				Mexico								•		•							
Instituto Geographico etc	1963		•				Columbia										•							
ISRA	1992		•									•	•											

		Scale							Biome				Data coll'n			Output		Application								
Author/Agency	Date	Land use	Land cover	Global	Continental	Regional	National	Sub-National	Tropics	Temperate	Polar	Remote Sensing/API	Ground Survey	Census	Mapping	Statistics	Vegetation	Agriculture	Forestry	Urban	Arid	Conservation	Biogeog/Biodiversity	Climate Change
ITC	1993	•															•							
IUCN	1973		•	•																				
IUCN	1990		•																			•		
IUFRO	1992		•	•															•					
James et al (Times Atlas)	no date		•	•											•		•							
Japan		•					Japan																	
Justice & Kendall	199 ?		•		Africa				•			•							•					
Koomanoff	1989		•	•								•			•		•						•	
Kostrowicki	1983	•																•						
Kuchler	1949		•														•							
Kuchler	1967		•												•		•							
Kuchler & Zonneveld	1988		•	•											•			•						
Kuhnholz-Lordat	1949		•												•		•							
Lavena	1987		•		Africa										•		•							
LCWG of the AARS	1995		•		Asia							•												
Legris & Blasco	1972		•	•								•	•		•		•							
Lloyd	1990		•									•					•							
Loveland et al	1991		•				USA					•												
Lowe et al	1994						Canada												•					
Malaysia	?	•					Malaysia																	
Matthews	1983	•	•	•											•		•							•
Millington et al	1994		•		Africa										•				•		•			
Min of Agric, Bhutan	1994	•	•				Bhutan		•	•		•			•	•	•	•	•					
MSU	1986	•		•											•									
MSU	1993		•	•											•									
Mucher et al	1993	•		•																				
National Land Agency	1959-	•						•		•				•	•									
National Land Agency	1970-79	•					Japan			•				•	•									
Nature Conservancy (USA)	1994		•				USA										•							
Olsen & Dinnerstein	in prep		•		Africa				•								•							
Olsen & Watts	1982		•	•													•							
Olsen, Watts & Allison	1982		?	•													•							
Paijmans	1975		•				Papua N G		•						•		•							
PFI	1987		•				Pakistan												•					
Pratt, Greenway & Gwynne	1966		•			E. Africa																		
Quintanilla	1995		•				Chili			•									•					
RADMBRAZIL	1973-	•	•				Brazil	•							•		•							
Remmelzwaal	1989	•		•																				
Rivard et al	1990	•					Cameroun					•												
Running et al	1994		•	•			Haiti					•					•							
Sayer et al	1992				Africa				•						•				•			•		
Schultink	1992	•	•				Haiti					•												
Sharma	1986a		•		Asia				•						•		•							
Sharma	1986b		•		Asia				•						•		•							
Sharma	1988		•		Africa										•		•							
Sims	1992	•		•																				
Sims	1993	•		•														•						
SNVCS	1994		•				USA																	
Sombroek	1993	•		•																				
SSP	1963	•					Pakistan																	
Stewart	1987	•					Nepal																	
Stomph & Fresco	1991	•																•						
Tamraker	1986	•					Nepal					•			•			•	•					
TER.UTI	- ? -	•	•				France									•								
Thailand	- ? -	•					Thailand																	
Thompson	1994		•			Sthern Afr			•	•		•			•	•	•	•	•	•	•	•		•
Townshend et al	1987		•		S America							•												
Townshend et al	1991		•	•								•												
Tucker et al	1985		•		Africa							•												
Udvardy	1975														•								•	
UN	1990	•		•												•								
UNDP/FAO	1994		•				Cambodia		•			•			•		•	•						
UN-ECE/FAO	1990	•	•							•									•					
UN-ECE/FAO	1992	•	•							•									•					
UNESCO	1973		•	•											•		•							
UNESCO	1981		•		S America										•		•							
US Geological Survey	1986	•	•				USA																	
US Geological Survey	nd		•				Senegal		•			•							•					
Vietnam		•					Vietnam																	
Walter	1973		•	•											•		•							
WCMC	1992								•										•			•		
White	1983		•		Africa				•	•			•		•		•						•	
Whitmore	1978		•			Malesia									•		•							
Wyatt et al	1994	•	•				Great Britain																	
Yasuoka	1993		•				Japan					•	•		•		•							

ANNEX 5

Comparison of CORINE Land Cover Classes with Eight Land Classifications on the Basis of Attributes of Land Use

CORINE LAND COVER
1 Artificial Surfaces

CORINE LAND COVER
1 Artificial Surfaces

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.1 Residential Land
3.2 Industrial Land, excluding Quarries, Pits, etc.
3.3 Land used for Quarries, Pits, Mines, etc.
3.4 Commercial Land
3.5 Land used for Public Services
3.7 Land used for Transport and Communication
3.9.1 Parks, Green Areas, etc.
3.9.2 Recreational Land - Camp Sites, etc.
3.9.3 Land under Current Construction
7.1.2 Artificial Watercourses

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
02215 Preparing Cut Trees for Transport
04310 Pumping
04330 Handling of Extracted Material
04340 Placer Mining
07110 Transporting by Roads
07120 Transporting by Rail
07130 Transporting by Air
07140 Transporting by Water
07151 Transporting Gas
07152 Transporting Oil
08220 Processing Food and Tobacco
08230 Processing Natural Fibre Felt and Leather
08240 Processing Rock, Stone, Clay, Sand & Gravel
08250 Processing Ores and Metals
08260 Processing Coal and Refining Petroleum
08270 Processing Chemicals
08280 Processing Wood
08300 Processing Processed Goods
08400 Assembling Products
08500 Storage Activities
09000 Commercial Activities
10000 Institutional Services

EUROSTAT - CLUSTERS
A1 Residential Areas & Public Services
A2 Industrial Or Commercial Activities
A311 Technical Networks and Protective Structures
A32 Transport
A41 Extractive Industries
A421 Building Sites
A422 Tips
A502 Sports Facilities
A503 Green or Leisure Areas

YOUNG (1994)
3.1 Recreation
3.3.3 Industrial Activities
3.3.4 Settlement Infrastructure

ANDERSON *ET AL.* (1976)
1 Urban Or Built-up Land

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
6.2 Landfill Waste Disposal
7.1 Indoor Recreation
7.2 Outdoor Recreation
8 Transport
9 Residential
10 Community Buildings
11.1 Industry
11.2 Offices
11.3 Retailing
11.6 Agricultural Buildings

CORINE LAND COVER
1.1 Urban Fabric
1.1.1 Continuous Urban Fabric
1.1.2 Discontinuous Urban Fabric

CORINE LAND COVER
1.1 Urban Fabric
1.2 Industrial, Commercial & Transport Units

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.1 Residential Land
3.4 Commercial Land
3.5 Land used for Public Services
3.7 Land used for Transport and Communication

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
02215 Preparing Cut Trees for Transport
07111 Transporting by Expressways (Limited Access)
07112 Provincial Highways
07113 Lower Order Rural Roads
07114 Urban Roads and Streets
07116 Associated Building and Maintaining
07118 Parking
07121 Transporting by Rail
07122 Railway Building and Maintenance
07124 Switching & Storing Transportation Equipment
07131 Landing & Taking Off (Runways) International
07132 Landing & Taking Off (Runways) Domestic
07133 Landing & Taking Off (International & Domestic)
07135 Guiding Aircraft
07140 Transporting by Water
09100 Wholesaling
09200 Retailing
09300 Providing Commercial Services
10000 Institutional Services

EUROSTAT - CLUSTERS
A1 Residential Areas & Public Services
A203 Commerce and Finance
A204 Agricultural Holdings
A32 Transport

ANDERSON *ET AL.* (1972)
1.1 Residential
1.2 Commercial And Services
1.4 Transportation, Communications And Utilities

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
7.1 Indoor Recreation
8 Transport
9 Residential
10 Community Buildings
11.2 Offices
11.3 Retailing
11.6 Agricultural Buildings

CORINE LAND COVER
1.2 Industrial, Commercial & Transport Units

CORINE LAND COVER
1.1 Urban Fabric
1.2 Industrial, Commercial & Transport Units
1.3 Mine, Dump And Construction Sites

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.2 Industrial Land, excluding Quarries, Pits, etc.
3.4 Commercial Land
3.7 Land used for Transport and Communication

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
02215 Preparing Cut Trees for Transport
07110 Transporting by Roads
07120 Transporting by Rail
07130 Transporting by Air
07140 Transporting by Water
08220 Processing Food and Tobacco
08230 Processing Natural Fibre Felt and Leather
08240 Processing Rock, Stone, Clay, Sand & Gravel
08250 Processing Ores and Metals
08260 Processing Coal and Refining Petroleum
08270 Processing Chemicals
08280 Processing Wood
08300 Processing Processed Goods
08400 Assembling Products
08500 Storage Activities
09000 Commercial Activities

EUROSTAT - CLUSTERS
A210 Heavy Industry
A202 Manufacturing Industry
A203 Commerce and Finance
A32 Transport
A4 Extractive Industry, Building Sites, Tips, etc.

YOUNG (1994)
1.2 Commercial and Services
1.3 Industrial
1.4 Transportation, Communications and Utilities

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
8 Transport
11.1 Industry
11.2 Offices
11.3 Retailing

CORINE LAND COVER
1.2.1 Industrial or Commercial Units

CORINE LAND COVER
1.1 Urban Fabric
1.2 Industrial, Commercial & Transport Units
1.3 Mine, Dump And Construction Sites

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.2 Industrial Land, excluding Quarries, Pits, etc.
3.4 Commercial Land

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
08220 Processing Food and Tobacco
08230 Processing Natural Fibre Felt and Leather
08240 Processing Rock, Stone, Clay, Sand & Gravel
08250 Processing Ores and Metals
08260 Processing Coal and Refining Petroleum
08270 Processing Chemicals
08280 Processing Wood
08300 Processing Processed Goods
08400 Assembling Products
08500 Storage Activities
09000 Commercial Activities

EUROSTAT - CLUSTERS
A210 Heavy Industry
A202 Manufacturing Industry
A203 Commerce and Finance
A4 Extractive Industry, Building Sites, Tips, etc.

YOUNG (1994)
1.2 Commercial and Services
1.3 Industrial

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
11.1 Industry
11.2 Offices
11.3 Retailing

1.2.2 Road & Rail Networks & Associated Land

CORINE LAND COVER
1.1 Urban Fabric
1.2.2 Road & Rail Networks and Associated Land
1.2.2 Port Areas
1.2.4 Airports

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.7 Land used for Transport and Communication

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
02215 Preparing Cut Trees for Transport
07110 Transporting by Roads
07120 Transporting by Rail
07130 Transporting by Air
07140 Transporting by Water

EUROSTAT - CLUSTERS
A32 Transport

ANDERSON *ET AL.* (1976)
1.4 Transportation, Communications and Utilities

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
8 Transport

CORINE LAND COVER **1.2.3 Port Areas**	**CORINE LAND COVER** 1.2.3 Port Areas **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 07144 Docks and Wharves **EUROSTAT - CLUSTERS** A32 River and Maritime Transport **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 8.5 Docks
1.2.4 Airports	**CORINE LAND COVER** 1.2.4 Airports **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 3.7.3 Land under Airports & related facilities **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 07130 Transporting by Air **EUROSTAT - CLUSTERS** A323 Airports and Aerodromes **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 8.4 Airports
1.3 Mine, Dump & Construction Sites	**CORINE LAND COVER** 1.3.2 Dump Sites 1.3.3 Construction Sites **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 3.3 Land used for Quarries, Pits, Mines, etc. 3.9.3 Land under Current Construction **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 08000 Manufacturing and Storing Activities **EUROSTAT - CLUSTERS** A421 Building Sites A422 Tips **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 6.2 Landfill Waste Disposal

CORINE LAND COVER **1.3.1 Mineral Extraction Sites**	**CORINE LAND COVER** 1.3.1 Mineral Extraction Sites **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 3.3 Land used for Quarries, Pits, Mines, etc. **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 04310 Pumping 04330 Handling of Extracted Material 04340 Placer Mining 07151 Transporting Gas 07152 Transporting Oil **EUROSTAT - CLUSTERS** A311 Technical Networks and Protective Structures A41 Extractive Industries
1.3.2 Dump Sites	**CORINE LAND COVER** 1.3.2 Dump Sites **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 3 Built-up & Related Land. **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 08000 Manufacturing and Storing Activities **EUROSTAT - CLUSTERS** A422 Tips **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 6.2 Landfill Waste Disposal
1.3.3 Construction Sites	**CORINE LAND COVER** 1.3.3 Construction Sites **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 3.9.3 Land under Current Construction **EUROSTAT - CLUSTERS** A42 Building Sites, Tips & Waste Land
1.4 Artificial Non-Agricultural Vegetated Areas **1.4.2 Sport & Leisure Facilities**	**CORINE LAND COVER** 1.4 Artificial Non-Agricultural Vegetated Areas **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 3.9.1 Parks, Green Areas, etc. 3.9.2 Recreational Land - Camp Sites, etc. **EUROSTAT - CLUSTERS** A502 Sports Facilities **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 7.2 Outdoor Recreation

CORINE LAND COVER
I.4.1 Green Urban Areas

CORINE LAND COVER
1.4 Artificial Non-Agricultural Vegetated Areas

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9.1 Parks, Green Areas, etc.
3.9.2 Recreational Land - Camp Sites, etc.

EUROSTAT - CLUSTERS
A502 Sports Facilities

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
7.2 Outdoor Recreation

CORINE LAND COVER
2 Agricultural Areas

CORINE LAND COVER
2 Agricultural Areas
3.1 Forests

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
1.1 Arable Land
1.2 Land under permanent crops
1.3 Land under permanent Meadows and Pasture
2.1.1 Coniferous Forest for Wood Production
2.2.1 Broadleaved Forest - Wood Production
2.3.1 Mixed Forest - Wood Production

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
01110 Growing Annual Tillage Crops
01120 Growing Forage Crops and Grazing
01130 Fruit and Berry Production
01140 Growing Ornamental Shrubs and Trees
01150 Sod Production
01220 Outside Animal Feeding and Holding
01280 Beekeeping and Honey Making
02110 Logging and Cutting of Trees
02120 Gathering Treeseed and Raising Seed
02140 Tapping of Maple Trees
02150 Growing Christmas Trees
02160 Holly Production
03112 Food Hunting
03120 Trapping
03140 Commercial Fishing Lakes

EUROSTAT - CLUSTERS
B1 Tilled And Fallow Land
B21 Temporary and Artificial Grazing
B22 Permanent Pastures and Grazings
B3 Permanent Crops
C Forests
C1 Wooded Forest Areas
C22 Other Unproductive Forestry Areas

YOUNG (1994)
1.3 Collection
2.1 Production And Multi-Purpose Forestry
2.2.1 Nomadic Grazing
2.2.2 Extensive Grazing
2.2.3 Intensive Livestock Production
2.2.5 Shifting Cultivation
2.2.6 Sedentary Cultivation: Permanent Cropping
2.2.7 Sedentary Cultivation: Temporary Cropping
2.2.8 Wetland Cultivation
2.3 Production of Fish and Related Products

ANDERSON *ET AL.* (1976)
2 Agricultural Land
3 Rangeland
4 Forest Land

FOOD AND AGRICULTURAL ORGANISATION (1990)
1 Agricultural Land
2 Woodland Or Forest

MÜCHER ET AL. (1993)
2 Biomass Production

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.1 Field Crops
1.4 Horticulture and Orchards
1.5 Improved Pasture
2.1 Conifer Woodland
2.2 Mixed Woodland
2.3 Broadleaved Woodland
2.4 Undifferentiated Young Woodland
3.1 Unimproved Grassland

CORINE LAND COVER **2.1 Arable Land**	**CORINE LAND COVER** 2.1 Arable Land **EUROSTAT - CLUSTERS** B11 Cereals B12 Root and Industrial Crops B13 Vegetables and Flowers **YOUNG (1994)** 2.2.7 Sedentary Cultivation: Temporary Cropping 2.2.8 Wetland Cultivation **FOOD AND AGRICULTURAL ORGANISATION (1990)** 1.1.1.1 Land under temporary crops in open air **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 1.1 Field Crops
2.1.1 Non-Irrigated Land	**CORINE LAND COVER** 2.1.1 Non-Irrigated Arable Land
2.1.2 Permanently Irrigated Land	**CORINE LAND COVER** 2.1.2 Permanently Irrigated Land
2.1.3 Rice Fields	**CORINE LAND COVER** 2.1.3 Rice Fields
2.2 Permanent Crops	**CORINE LAND COVER** 2.2 Permanent Crops 3.1 Forests **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 1.2 Land under permanent crops 2.1.1 Coniferous Forest for Wood Production 2.2.1 Broadleaved Forest - Wood Production 2.3.1 Mixed Forest - Wood Production **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 02112 Cutting Sawtimber 02150 Growing Christmas Trees 02160 Holly Production **EUROSTAT - CLUSTERS** B36 Permanent Industrial Crops C14 Intensively Managed Plantations C22 Other Unproductive Forestry Areas **YOUNG (1994)** 2.1.1 Management of Natural Forests 2.1.2 Management of Planted Forests 2.2.6 Sedentary Cultivation: Permanent Cropping **ANDERSON *ET AL.* (1976)** 2.2 Orchards, Groves, Vineyards, Nurseries **FOOD AND AGRICULTURAL ORGANISATION (1990)** 1.1.3 Land under Permanent Crops

CORINE LAND COVER **2.2.1 Vineyards**	**CORINE LAND COVER** 2.2.1 Vineyards
2.2.2 Fruit Trees & Berry Plantations	**CORINE LAND COVER** 2.2.2 Fruit Trees and Berry Plantations
2.2.3 Olive Groves	**CORINE LAND COVER** 2.2.3 Olive Groves
2.3 Pastures	**CORINE LAND COVER** 2.3 Pastures **EUROSTAT - CLUSTERS** B21 Temporary and Artificial Grazing B22 Permanent Pastures and Grazings **FOOD AND AGRICULTURAL ORGANISATION (1990)** 1.2.1 Managed grassland

CORINE LAND COVER
2.4 Heterogeneous Agricultural Areas

CORINE LAND COVER
2 Agricultural Areas
3.1 Forests

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
1.1 Arable Land
1.2 Land under permanent crops
1.3 Land under permanent Meadows and Pasture
2.1.1 Coniferous Forest for Wood Production
2.2.1 Broadleaved Forest - Wood Production
2.3 Land Under Mixed Forest

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
01110 Growing Annual Tillage Crops
01120 Growing Forage Crops and Grazing
01130 Fruit and Berry Production
01140 Growing Ornamental Shrubs and Trees
01150 Sod Production
01220 Outside Animal Feeding and Holding
01280 Beekeeping and Honey Making
02110 Logging and Cutting of Trees
02120 Gathering Treeseed and Raising Seed
02140 Tapping of Maple Trees
02150 Growing Christmas Trees
02160 Holly Production
03112 Food Hunting
03120 Trapping
03130 Preserving Wildlife

EUROSTAT - CLUSTERS
B1 Tilled And Fallow Land
B2 Areas under Grass, used for Agriculture
B3 Permanent Crops
C Forests
C1 Wooded Forest Areas
C22 Other Unproductive Forestry Areas

YOUNG (1994)
1.3 Collection
2.1 Production And Multi-Purpose Forestry
2.2.1 Nomadic Grazing
2.2.2 Extensive Grazing
2.2.3 Intensive Livestock Production
2.2.5 Shifting Cultivation
2.2.6 Sedentary Cultivation: Permanent Cropping
2.2.7 Sedentary Cultivation: Temporary Cropping
2.2.8 Wetland Cultivation
2.3 Production of Fish and Related Products

ANDERSON *ET AL.* (1976)
2 Agricultural Land
3 Rangeland
4 Forest Land

FOOD AND AGRICULTURAL ORGANISATION (1990)
1 Agricultural Land
2 Woodland or Forest

MÜCHER ET AL. (1993)
2 Biomass Production

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.1 Field Crops
1.4 Horticulture and Orchards
1.5 Improved Pasture
2.1 Conifer Woodland
2.2 Mixed Woodland
2.3 Broadleaved Woodland
2.4 Undifferentiated Young Woodland
3.1 Unimproved Grassland

CORINE LAND COVER **2.4.2 Complex Cultivation Patterns** **2.4.3 Mixture of Agricultural & Natural Land**	**CORINE LAND COVER** 2 Agricultural Areas 3.1 Forests **UN/ECE STATISTICAL CLASSIFICATION OF LAND USE** 1.1 Arable Crops 1.2 Land under permanent crops 1.3 Land under Permanent Meadows and Pasture 2.1.1 Coniferous Forest for Wood Production 2.2.1 Broadleaved Forest - Wood Production 2.3.1 Mixed Forest - Wood Production **CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING** 01110 Growing Annual Tillage Crops 01120 Growing Forage Crops and Grazing 01130 Fruit and Berry Production 01140 Growing Ornamental Shrubs and Trees 01150 Sod Production 02112 Cutting Sawtimber 02150 Growing Christmas Trees 02160 Holly Production **EUROSTAT - CLUSTERS** B12 Root and Industrial Crops B13 Vegetables and Flowers B21 Temporary and Artificial Grazing B22 Permament Pastures and Grazing B3 Permanent Crops C14 Intensively Managed Plantations C22 Other Unproductive Forestry Areas **YOUNG (1994)** 2.1 Production and Multi-Purpose Forestry 2.2.5 Shifting Cultivation 2.2.6 Sedentary Cultivation: Permanent Cropping 2.2.7 Sedentary Cultivation: Temporary Cropping 2.2.8 Wetland Cultivation **ANDERSON *ET AL.* (1976)** 2.2 Orchards, Groves, Vineyards, Nurseries **FOOD AND AGRICULTURAL ORGANISATION (1990)** 1.1.1.1 Land Under Temporary Crops in Open Air 1.1.1.2 Land under Temporary Meadows 1.1.3 Land Under Permanent Crops 1.2.1 Managed Grassland **MÜCHER ET AL. (1993)** 2.1.2 Introduced Natural Perennial Cover 2.1.3 Introduced Natural Annual Cover 2.1.4 Introduced Natural Cover - Annual-Fallow 2.1.5 Introduced Natural Cover - Annual-Perennial 2.1.6 Primary Production Under Artificial Cover **CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM** 1.1 Field Crops 1.4 Horticulture and Orchards 1.5 Improved Pasture
2.4.4 Agroforestry Areas	**CORINE LAND COVER** 2.4.4 Agroforestry Areas

CORINE LAND COVER
3 Forests & Semi-Natural Areas

CORINE LAND COVER
2.1 Arable Land
2.2 Permanent Crops
2.4.1 Annual Crops associated with Permanent Crops
3 Forests And Semi-Natural Areas
4.1 Inland Wetlands
4.2.1 Salt Marshes

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
1.2 Land under permanent crops
2.1.1 Coniferous Forest for Wood Production
2.2.1 Broadleaved Forest - Wood Production
2.3.1 Mixed Forest - Wood Production
4 Wet Open Land
5 Dry Open Land with Special Vegetation
6 Open Land Without Significant Vegetation
7.2 Tidal Waters

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
01110 Growing Annual Tillage Crops
01140 Growing Ornamental Shrubs and Trees
01150 Sod Production
02110 Logging and Cutting of Trees
02120 Gathering Treeseed and Raising Seed
02140 Tapping of Maple Trees
02150 Growing Christmas Trees
02160 Holly Production
12000 Unused Idle Land

EUROSTAT - CLUSTERS
B1 Tilled and Fallow Land
B3 Permanent Crops
C1 Wooded Forest Areas
C22 Other Unproductive Forestry Areas
D Bush Or Herbaceous Areas
E Surfaces With Little Or No Vegetation
F1 Wet Surfaces

YOUNG (1994)
1.1 Not Used
1.3.1 Collection of Plant Products
1.3.3 Collection of Plant and Animal Products
2.1 Production And Multi-Purpose Forestry
2.2.5 Shifting Cultivation
2.2.6 Sedentary Cultivation: Permanent Cropping
2.2.7 Sedentary Cultivation: Temporary Cropping
2.2.8 Wetland Cultivation

ANDERSON *ET AL.* (1976)
2.2 Orchards, Groves, Vineyards, Nurseries
3 Rangeland
4 Forest Land
5.4 Bays And Estuaries
6 Wetland
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exposed Rock
8 Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
1.1.1.1 Land Under Temporary Crops in Open Air
1.1.2 Land Under Protective Cover
1.1.3 Land Under Permanent Crops
1.2.2 Natural grassland
2 Woodland or Forest
3 Unused and Undeveloped Land

CORINE LAND COVER
3 Forests & Semi-Natural Areas

MÜCHER ET AL. (1993)
1 Unused
2.1.1 Natural Biomass Extraction
2.1.6 Primary Production Under Artificial Cover

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.1 Field Crops
1.2 Ploughed Fields
1.3 Fallow Land
1.4 Horticulture and Orchards
1.6 Field Margins
2.1 Conifer Woodland
2.2 Mixed Woodland
2.3 Broadleaved Woodland
2.4 Undifferentiated Young Woodland
2.5 Scrub
2.6 Felled Woodland
3 Unimproved Grassland and Heathland
4.1 Sea / Estuary
4.4 Freshwater Marsh
4.5 Salt Marsh
4.6 Bog
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

3.1 Forests
3.1.1 Broadleaved Forest
3.1.2 Coniferous Forest
3.1.3 Mixed Forest

CORINE LAND COVER
3.1 Forests

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
2.1.1 Coniferous Forest for Wood Production

EUROSTAT - CLUSTERS
C14 Intensively Managed Plantations

3.2 Shrub / Herbaceous Vegetation Associations
3.2.1 Natural Grassland
3.2.2 Moors & Heathland
3.2.3 Sclerophyllous Vegetation
3.2.4 Transitional Woodland / Scrub

CORINE LAND COVER
3.2 Shrub/Herbaceous Vegetation Associations
4.1 Inland Wetlands
4.2.1 Salt Marshes

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
4 Wet Open Land
5 Dry Open Land With Special Vegetation

EUROSTAT - CLUSTERS
D Bush Or Herbaceous Areas
F1 Wet Surfaces

ANDERSON *ET AL.* (1976)
6 Wetland
8.1 Shrub And Brush Tundra
8.2 Herbaceous Tundra
8.4 Wet Tundra

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.6 Field Margins
2.5 Scrub
3.2 Heathland
3.3 Bracken
4.4 Freshwater Marsh
4.5 Salt Marsh
4.6 Bog
5.4 Dunes

CORINE LAND COVER
3.3 Open Spaces with little or no Vegetation
3.3.1 Beaches, Dunes & Sand Plains
3.3.2 Bare Rocks
3.3.3 Sparsely Vegetated Areas
3.3.4 Burnt Areas
3.3.5 Glaciers & Permanent Snowfields

CORINE LAND COVER
3.3 Open Spaces With little or no Vegetation
4.2.3 Inter-Tidal Flats

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
6 Open Land Without Significant Vegetation

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
01190 Other
12000 Unused Idle Land

EUROSTAT - CLUSTERS
B14 Fallow Land, Including Green Manure
E Surfaces With Little Or No Vegetation
F101 Bogs & Marshes
F103 Other Wet Areas
F301 Estuaries And Lagoons

YOUNG *ET AL.* (1996)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exxposed Rock
8 Tundra
8.3 Bare Ground Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused and Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
4.1 Sea / Estuary
5 Rock And Coastal Land
12 Vacant Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
4 Wetlands

CORINE LAND COVER
3.2 Shrub/Herbaceous Vegetation Associations
3.3 Open Spaces With little or no Vegetation
4 Wetlands
5 Water Bodies
5.1 Inland Waters
5.1.2 Water Bodies

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9 Recreational And Other Land
4 Wet Open Land
5 Dry Open Land With Special Vegetation
6 Open Land Without Significant Vegetation
7.1.2 Artificial Watercourses

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
04262 Mining Salt
12000 Unused Idle Land

EUROSTAT - CLUSTERS
A4 Extractive Industry, Building Sites, Tips, etc.
D Bush Or Herbaceous Areas
E Surfaces With Little Or No Vegetation
F1 Wet Surfaces

YOUNG *ET AL.* (1996)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
6 Wetland
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exxposed Rock
8 Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused and Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
1.6 Field Margins
2.5 Scrub
3 Unimproved Grassland and Heathland
3.2 Heathland
3.3 Bracken
4 Water And Wetland
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
4.1 InlandWetlands
4.1.1 Inland Marshes
4.1.2 Peat Bogs

CORINE LAND COVER
3.2 Shrub/Herbaceous Vegetation Associations
4.1 Inland Wetlands
4.2.1 Salt Marshes

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
4 Wet Open Land
5 Dry Open Land With Special Vegetation

EUROSTAT - CLUSTERS
D Bush Or Herbaceous Areas
F1 Wet Surfaces

ANDERSON *ET AL.* (1976)
6 Wetland
8.1 Shrub And Brush Tundra
8.2 Herbaceous Tundra
8.4 Wet Tundra

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.6 Field Margins
2.5 Scrub
3.2 Heathland
3.3 Bracken
4.4 Freshwater Marsh
4.5 Salt Marsh
4.6 Bog
5.4 Dunes

CORINE LAND COVER
4.2 Maritime Wetlands

CORINE LAND COVER
3.2 Shrub/Herbaceous Vegetation Associations
3.3 Open Spaces With Little Or No Vegetation
4 Wetlands
5 Water Bodies

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9 Recreational And Other Land
4 Wet Open Land
5 Dry Open Land With Special Vegetation
6 Open Land Without Significant Vegetation

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
04262 Mining Salt
12000 Unused Idle Land

EUROSTAT - CLUSTERS
A4 Extractive Industry, Building Sites, Tips, etc.
D Bush Or Herbaceous Areas
E Surfaces With Little Or No Vegetation
F1 Wet Surfaces

YOUNG, (1994)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
6 Wetland
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exposed Rock
8 Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused And Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
1.6 Field Margins
2.5 Scrub
3 Unimproved Grassland And Heathland
3.2 Heathland
3.3 Bracken
4 Water And Wetland
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
4.2.1 Salt Marshes

CORINE LAND COVER
3.2 Shrub/Herbaceous Vegetation Associations
4.1 Inland Wetlands
4.2 Maritime Wetlands

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
4 Wet Open Land
5 Dry Open Land with Special Vegetation

EUROSTAT - CLUSTERS
D Bush Or Herbaceous Areas
F1 Wet Surfaces

ANDERSON *ET AL.* (1976)
6 Wetland
8.1 Shrub And Brush Tundra
8.2 Herbaceous Tundra
8.4 Wet Tundra

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.6 Field Margins
2.5 Scrub
3.2 Heathland
3.3 Bracken
4.4 Freshwater Marsh
4.5 Salt Marsh
4.6 Bog
5.4 Dunes

4.2.2 Salines

CORINE LAND COVER
4.2.2 Salines

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
04262 Mining Salt

4.2.3 Inter-Tidal Flats

CORINE LAND COVER
3.3.2 Bare Rocks
3.3.5 Glaciers and Permanent Snowfields
4.2.3 Inter-Tidal Flats

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
6 Open Land Without Significant Vegetation

EUROSTAT - CLUSTERS
E Surfaces With Little Or No Vegetation

YOUNG, (1994)
1.1 Not Used

ANDERSON *ET AL.* (1976)
7.1 Dry Salt Flats
7.2 Beaches
7.4 Bare Exposed Rock
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused and Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
5.1 Inland Rock
5.2 Coastal Rocks and Cliffs
5.3 Inter-Tidal Sand and Mud
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
5 Water Bodies
5.1 Inland Waters
5.1.1 Water Courses

CORINE LAND COVER
3.3 Open Spaces With Little Or No Vegetation
4.1.2 Peat Bogs
5 Water Bodies

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9 Recreational and other Land
6 Open Land without Significant Vegetation
7.1.2 Artificial Watercourses
7.1.4 Artificial Water Impoundment
7.2 Tidal Waters

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
04220 Extraction Of Water
07142 Travelling By Canal
12000 Unused Idle Land

EUROSTAT - CLUSTERS
A324 River And Maritime Transport
A4 Extractive Industry, Building Sites, Tps, etc.
E Surfaces With Little Or No Vegetation
F1 Wet Surfaces

YOUNG, (1994)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exxposed Rock
8.3 Bare Ground Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused And Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused
4 Non-Biological Extraction

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
4.1 Sea / Estuary
4.2 Standing Water
4.3 Running Water
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
5 Water Bodies
5.1 Inland Waters
5.1.1 Water Courses

CORINE LAND COVER
3.3 Open Spaces With Little Or No Vegetation
4.1.2 Peat Bogs
5 Water Bodies

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9 Recreational and other Land
6 Open Land without Significant Vegetation
7.1.2 Artificial Watercourses
7.1.4 Artificial Water Impoundment
7.2 Tidal Waters

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
04220 Extraction Of Water
07142 Travelling By Canal
12000 Unused Idle Land

EUROSTAT - CLUSTERS
A324 River And Maritime Transport
A4 Extractive Industry, Building Sites, Tps, etc.
E Surfaces With Little Or No Vegetation
F1 Wet Surfaces

YOUNG, (1994)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exxposed Rock
8.3 Bare Ground Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused And Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused
4 Non-Biological Extraction

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
4.1 Sea / Estuary
4.2 Standing Water
4.3 Running Water
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
5.1.2 Inland Water Bodies

CORINE LAND COVER
3.3 Open Spaces With Little Or No Vegetation
4.2 Maritime Wetlands
5 Water Bodies

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9 Recreational and other Land
6 Open Land without Significant Vegetation
7.1.2 Artificial Watercourses
7.1.4 Artificial Water Impoundment
7.2 Tidal Waters

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
04220 Extraction Of Water
12000 Unused Idle Land

EUROSTAT - CLUSTERS
A4 Extractive Industry, Building Sites, Tps, etc.
E Surfaces With Little Or No Vegetation
F1 Wet Surfaces

YOUNG, (1994)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exposed Rock
8.3 Bare Ground Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused And Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused
4 Non-Biological Extraction

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
4.1 Sea / Estuary
4.2 Standing Water
4.3 Running Water
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

CORINE LAND COVER
5.2 Marine Waters
5.2.1 Coastal Lagoons
5.2.2 Estuaries
5.2.3 Sea & Ocean

CORINE LAND COVER
3.3 Open Spaces With Little Or No Vegetation
4.2.3 Inter-Tidal Flats
5 Water Bodies

UN/ECE STATISTICAL CLASSIFICATION OF LAND USE
3.9.4 Land For Future Construction
6 Open Land without Significant Vegetation
7.1.1 Natural Watercourses
7.2 Tidal Waters

CANADIAN LAND USE CLASSIFICATION FOR LAND USE MONITORING
01190 Other
12000 Unused Idle Land

EUROSTAT - CLUSTERS
A423 Waste Land Through Human Activities
E03 Burned Areas
F101 Bogs & Marshes
F103 Other Wet Areas
F301 Estuaries And Lagoons

YOUNG, (1994)
1.1 Not Used

ANDERSON *ET AL.* (1976)
5.4 Bays And Estuaries
7.1 Dry Salt Flats
7.2 Beaches
7.3 Sandy Areas Other Than Beaches
7.4 Bare Exposed Rock
8.3 Bare Ground Tundra
9 Perennial Snow Or Ice

FOOD AND AGRICULTURAL ORGANISATION (1990)
3 Unused And Undeveloped Land

MÜCHER ET AL. (1993)
1 Unused

CLASSIFICATION FOR UK NATIONAL LAND USE STOCK SYSTEM
1.3 Fallow Land
4.1 Sea / Estuary
4.2 Standing Water
4.3 Running Water
5 Rock And Coastal Land
12.2 Derelict Land
12.3 Vacant Land Previously Developed

ANNEX 6

Comparison of CORINE Land Cover Classes with Eight Land Classifications on the Basis of Attributes of Land Cover

CORINE LAND COVER
1 Artificial Surfaces

RANGE & FOREST RESOURCES OF SENEGAL
Herbaceous Steppes
Urban and quarries
Primary paved roads
Earth roads
Railroads

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
IV.D.1 Mainly Bryophyte Tundra
V.A.4 Tall Grassland & Woody Synusia of Tuft Plants
V.B.3 Medium Tall Grassland (3)
V.C.3 Short Grassland (3)
V.C.4 Short Grassland (4)

VEGETATION MAP OF PAPUA NEW GUINEA
Montane forest
Savanna
Grassland

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Urban and Built-up

CORINE LAND COVER
1 Artificial Surfaces
2.4.2 Complex Cultivation Patterns
2.4.4 Agro-forestry Areas
3.3.1 Beaches, Dunes & Sand Plains
3.3.2 Bare Rocks
4.2.2 Salines

ANDERSON *ET AL.* (1976)
1 Urban or Built-up Land
2.4 Other Agricultural Land
7.1 Dry Salt Flats

CAMBODIA LAND COVER ATLAS
1 Urban/City
23 Flooded Grass

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
212 Built-up Area

CORINE LAND COVER **1.1 Urban Fabric** **1.2.1 Industrial or Commercial Units**	**RANGE & FOREST RESOURCES OF SENEGAL** Urban and quarries **IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Urban and Built-up **CORINE LAND COVER** 1.1 Urban Fabric 1.2.1 Industrial, Commercial & Transport Units 1.2.3 Port Areas 1.2.4 Airports 1.3.3 Construction Sites **ANDERSON *ET AL.* (1976)** 1.1 Residential 1.2 Commercial & Services 1.3 Industrial 1.5 Industrial & Commercial Complexes 1.6 Mixed Urban or Built-up Land 1.7 Other Urban or Built-up Land 2.4 Other Agricultural Land **CAMBODIA LAND COVER ATLAS** 1 Urban/City **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 212 Built-up Area
1.1.1 Continuous Urban Fabric	**CORINE LAND COVER** 1.1.1 Continuous Urban Fabric
1.1.2 Discontinuous Urban Fabric	**CORINE LAND COVER** 1.1.2 Discontinuous Urban Fabric
1.2 Industrial, Commercial & Transport Units	**RANGE & FOREST RESOURCES OF SENEGAL** Urban and quarries Primary paved roads Earth roads Railroads **IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Urban and Built-up **CORINE LAND COVER** 1.1 Urban Fabric 1.2 Industrial, Commercial and Transport Units 1.3.3 Construction Sites **ANDERSON *ET AL.* (1976)** 1 Urban or Built-up Land 2.4 Other Agricultural Land **CAMBODIA LAND COVER ATLAS** 1 Urban/City **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 212 Built-up Area

CORINE LAND COVER **1.2.2 Road & Rail Networks & Associated Land**	**RANGE & FOREST RESOURCES OF SENEGAL** Primary paved roads Earth roads Railroads **CORINE LAND COVER** 1.2.2 Road & Rail Networks & Associated Land **ANDERSON *ET AL.* (1976)** 1.4 Transportation, Communications & Utilities
1.2.3 Port Areas	**CORINE LAND COVER** 1.2.3 Port Areas
1.2.4 Airports	**CORINE LAND COVER** 1.2.4 Airports
1.3 Mine, Dump & Construction Sites	**RANGE & FOREST RESOURCES OF SENEGAL** Urban and quarries **CORINE LAND COVER** 1.1.2 Discontinuous Urban Fabric 1.2.4 Airports 1.3 Mine, Dump and Construction Sites 1.4 Artificial, Non-agricultural Vegetated Areas 3.3.2 Bare Rocks 4 Wetlands 4.2.2 Salines **ANDERSON *ET AL.* (1976)** 7.1 Dry Salt Flats
1.3.1 Mineral Extraction Sites	**RANGE & FOREST RESOURCES OF SENEGAL** Urban and quarries **CORINE LAND COVER** 1.1.2 Discontinuous Urban Fabric 1.3 Mine, Dump and Construction Sites 3.3.1 Beaches, Dunes & Sand Plains 3.3.2 Bare Rocks 4.2.2 Salines **ANDERSON *ET AL.* (1976)** 7.1 Dry Salt Flats
1.3.2 Dump Sites	**RANGE & FOREST RESOURCES OF SENEGAL** Urban and quarries **CORINE LAND COVER** 1.1.2 Discontinuous Urban Fabric 1.2.4 Airports 1.3 Mine, Dump and Construction Sites 3.3.1 Beaches, Dunes & Sand Plains 3.3.2 Bare Rocks 4.2.2 Salines **ANDERSON *ET AL.* (1976)** 6.1 Forested Wetland

CORINE LAND COVER
1.3.3 Construction Sites

RANGE & FOREST RESOURCES OF SENEGAL
Urban and quarries

CORINE LAND COVER
1.1.2 Discontinuous Urban Fabric
1.3.3 Construction Sites

1.4 Artificial non-Agricultural Vegetated Areas
1.4.1 Green Urban Areas

RANGE & FOREST RESOURCES OF SENEGAL
Herbaceous Steppes

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
IV.D Tundra
V.A.3 Tall Grassland & Synusia of Shrubs
V.A.4 Tall Grassland & Woody Synusia of Tuft Plants
V.B.3 Medium Tall Grassland (3)
V.C.3 Short Grassland (3)
V.C.4 Short Grassland (4)

VEGETATION MAP OF PAPUA NEW GUINEA
Montane forest
Savanna
Grassland

CORINE LAND COVER
1.2.4 Airports
1.4 Artificial, Non-agricultural Vegetated Areas
2.4.4 Agro-forestry Areas

CAMBODIA LAND COVER ATLAS
23 Flooded Grass

1.4.2 Sport & Leisure Facilities

RANGE & FOREST RESOURCES OF SENEGAL
Herbaceous Steppes

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
V.A Tall Graminoid Vegetation
V.B. Medium Tall Grassland
V.C.7 Short to Medium Tall Mesophytic Grassland

US FGDC VEGETATION CLASSIFICATION STANDARDS
V. Herbaceous

VEGETATION MAP OF PAPUA NEW GUINEA
Grassland
Mixed Herbaceous Vegetation

CORINE LAND COVER
1.4.2 Sport & Leisure Facilities
2.3 Pastures

CAMBODIA LAND COVER ATLAS
2 Paddy Fields
3 Receding & Floating Rice Fields
21 Grasslands
22 Grass Savannah
24 Abandoned Rice Fields

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
140 Agricultural Land - Grass Crops

CORINE LAND COVER
2 Agricultural Areas

RANGE & FOREST RESOURCES OF SENEGAL
Herbaceous Steppes

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
IV.D Tundra
V.A.3 Tall Grassland & Synusia of Shrubs
V.A.4 Tall Grass. & Woody Synusia of Tuft Plants
V.B.3 Medium Tall Grassland (3)
V.C.3 Short Grassland (3)
V.C.4 Short Grassland (4)

VEGETATION MAP OF PAPUA NEW GUINEA
Montane forest
Savanna
Grassland
Garden

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Croplands

CORINE LAND COVER
1.1.2 Discontinuous Urban Fabric
1.2.4 Airports
1.3 Mine, Dump and Construction Sites
1.4.1 Green Urban Areas
2.1 Arable Land
2.1.3 Rice Fields
2.2 Permanent Crops
2.3.1 Pastures
2.4.1 Annual Crops Associated with Permanent Crops
2.4.2 Complex Cultivation Patterns
2.4.4 Agro-forestry Areas
3.3.1 Beaches, Dunes & Sand Plains
4.2.2 Salines

ANDERSON *ET AL.* (1976)
2.1 Cropland & Pastures
2.2 Orchards, Groves, Vineyards, Nurseries etc.
7.1 Dry Salt Flats

CAMBODIA LAND COVER ATLAS
2 Paddy Fields
3 Receding & Floating Rice Fields
4 Upland Crops
5 Swidden Agriculture
6 Orchards
8 Field Crops
23 Flooded Grass

2.1 Arable Land

VEGETATION MAP OF PAPUA NEW GUINEA
Garden

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Croplands

CORINE LAND COVER
1.1.2 Discontinuous Urban Fabric
1.3 Mine, Dump and Construction Sites
1.4.1 Green Urban Areas
2.1 Arable Land
2.1.3 Rice Fields
4.2.2 Salines

ANDERSON *ET AL.* (1976)
2.1 Cropland & Pastures
7.1 Dry Salt Flats

CAMBODIA LAND COVER ATLAS
2 Paddy Fields
3 Receding & Floating Rice Fields
4 Upland Crops
5 Swidden Agriculture
8 Field Crops

CORINE LAND COVER **2.1.1 Non-irrigated Land** **2.1.2 Permanently Irrigated Land**	**VEGETATION MAP OF PAPUA NEW GUINEA** Garden **IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Croplands **CORINE LAND COVER** 1.1.2 Discontinuous Urban Fabric 1.3 Mine, Dump and Construction Sites 1.4.1 Green Urban Areas 2.1 Arable Land 3.3.1 Beaches, Dunes & Sand Plains 4.2.2 Salines **ANDERSON *ET AL.* (1976)** 2.1 Cropland & Pastures 7.1 Dry Salt Flats **CAMBODIA LAND COVER ATLAS** 2 Paddy Fields 3 Receding & Floating Rice Fields 4 Upland Crops 5 Swidden Agriculture 7 Plantation
2.1.3 Rice Fields	**CORINE LAND COVER** 2.1.3 Rice Fields **CAMBODIA LAND COVER ATLAS** 2 Paddy Fields 3 Receding & Floating Rice Fields
2.2 Permanent Crops	**CORINE LAND COVER** 2.2 Permanent Crops
2.2.1 Vineyards	**CORINE LAND COVER** 2.2.1 Vineyards
2.2.2 Fruit Trees & Berry Plantations	**CORINE LAND COVER** 2.2.1 Vineyards
2.2.3 Olive Groves	**CORINE LAND COVER** 2.2.3 Olive Groves

CORINE LAND COVER **2.3 Pastures**	**RANGE & FOREST RESOURCES OF SENEGAL** Herbaceous Steppes **UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION** IV.D Tundra V.A.3 Tall Grassland & Synusia of Shrubs V.A.4 Tall Grass. & Woody Synusia of Tuft Plants V.B.3 Medium Tall Grassland (3) V.C.3 Short Grassland (3) V.C.4 Short Grassland (4) **VEGETATION MAP OF PAPUA NEW GUINEA** Montane forest Savanna Grassland **CORINE LAND COVER** 1.2.4 Airports 1.4.1 Green Urban Areas 2.3.1 Pastures 2.4.2 Complex Cultivation Patterns 2.4.4 Agro-forestry Areas **ANDERSON *ET AL.* (1976)** 2.1 Cropland & Pastures **CAMBODIA LAND COVER ATLAS** 23 Flooded Grass
2.4 Heterogeneous Agricultural Areas	**VEGETATION MAP OF PAPUA NEW GUINEA** Garden **IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Croplands **CORINE LAND COVER** 1.4.1 Green Urban Areas 2.1 Arable Land 2.2 Permanent Crops 2.4.1 Annual Crops Associated with Permanent Crops 2.4.2 Complex Cultivation Patterns 2.4.4 Agro-forestry Areas **ANDERSON *ET AL.* (1976)** 2.1 Cropland & Pastures 2.2 Orchards, Groves, Vineyards, Nurseries etc. **CAMBODIA LAND COVER ATLAS** 2 Paddy Fields 3 Receding & Floating Rice Fields 4 Upland Crops 5 Swidden Agriculture 6 Orchards 8 Field Crops
2.4.1 Annual Crops Associated with Permanent Crops	**CORINE LAND COVER** 2.4.1 Annual Crops Associated with Permanent Crops
2.4.2 Complex Cultivation Patterns	**CORINE LAND COVER** 2.4.2 Complex Cultivation Patterns

CORINE LAND COVER
2.4.3 Land Principally Agricultural with Significant Areas of Natural Vegetation

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
V.E Hydromorphic Fresh-Water Vegetation (aquatic)

VEGETATION MAP OF PAPUA NEW GUINEA
Pioneer Vegetation

CORINE LAND COVER
1.1.2 Discontinuous Urban Fabric
2.4.1 Annual Crops Associated with Permanent Crops
2.4.2 Complex Cultivation Patterns
2.4.3 Land Principally Agricultural with Significant Areas of Natural Vegetation
3.2.2 Moors & Heathland
3.3 Open Spaces with Little or no Vegetation
4.1.2 Peat Bogs

ANDERSON *ET AL.* (1976)
1.1 Residential
1.2 Commercial & Services
1.3 Industrial
1.5 Industrial & Commercial Complexes
1.6 Mixed Urban or Built-up Land
1.7 Other Urban or Built-up Land
3 Rangeland
8.5 Mixed Tundra

CAMBODIA LAND COVER ATLAS
20 Swamps

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
10 Vegetation
174 Swamp
180 Tundra
196 Semi-desert

2.4.4 Agro-forestry Areas

CORINE LAND COVER
2.4.4 Agro-forestry Areas

CORINE LAND COVER
3. Forests & Semi-Natural Areas

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION

I Closed Forest
II.C.1 Sclerophyllous-dominated extremely xeromorphic woodland
IV.D Tundra
IV.E Mossy Bog Formations with Dwarf-Shrub
V.A Tall Graminoid Vegetation
V.B. Medium Tall Grassland
V.C. Short Grassland
V.D Forb Vegetation

US FGDC VEGETATION CLASSIFICATION STANDARDS

Tree Dominated
Shrub Dominated
Herb Dominated V. Herbaceous
Herb Dominated VI. Non-Vascular Dominated

VEGETATION MAP OF PAPUA NEW GUINEA

Forest
Grassland
Mixed Herbaceous Vegetation

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'

Grasslands
Snow and Ice
Barren

CORINE LAND COVER

1.4.2 Sport & Leisure Facilities
3 Forests and Semi-Natural Areas

ANDERSON *ET AL.* (1976)

3.1 Rangeland
4 Forest Land
6.2 Non-forested Wetland
7.2 Beaches
7.3 Sandy Areas other than Beaches
7.4 Bare Exposed Rock

CAMBODIA LAND COVER ATLAS

19 Abandoned Shrublands
21 Grasslands
22 Grass Savannah
24 Abandoned Grasslands
25 Marches

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING

140 Agricultural Land - Grass Crops
198 Rocks
210 Perennial Snow or Ice

CORINE LAND COVER
3.1 Forests

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
I.A.2a Tropical/subtropical evergreen seasonal lowland forest
I.A.2b Tropical/subtropical evergreen seasonal submontane forest
I.A.2c Tropical/subtropical evergreen seasonal montane forest
I.B.3 Cold-deciduous forest without evergreen trees
I.C.1 Sclerophyllous-dominated extremely xeromorphic forest
II.C.1 Sclerophyllous-dominated extremely xeromorphic woodland

US FGDC VEGETATION CLASSIFICATION STANDARDS
I. Closed Tree Canopy
II.A Open canopy, evergreen
II.B Open canopy, deciduous
II.C.1 Open canopy mixed evergreen-deciduous tropical and subtropical
II.C.1 Open canopy mixed evergreen-deciduous cold deciduous broad-leaved
II.C.1 Open canopy mixed evergreen-deciduous cold deciduous needle-leaved

VEGETATION MAP OF PAPUA NEW GUINEA
Small-crowned lowland hill forest
Coniferous lower montane forest
Dry evergreen forest

CORINE LAND COVER
3.1 Forests

ANDERSON *ET AL.* (1976)
4.1 Deciduous Forest Land
4.2 Evergreen Forest Land

CAMBODIA LAND COVER ATLAS
22 Grass Savannah

3.1.1 Broad-leaved Forest

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
I.A.2a Tropical/subtropical evergreen seasonal lowland forest
I.A.2b(1) Tropical/subtropical broadleaved evergreen seasonal submontane forest
I.A.2c Tropical/subtropical evergreen seasonal montane forest

US FGDC VEGETATION CLASSIFICATION STANDARDS
I.A.1. Closed canopy evergreen tropical rain forests
I.A.2. Closed canopy tropical and subtropical seasonal forests
I.A.3. Closed canopy evergreen subtropical broad-leaved rainforest
I.A.5. Closed canopy evergreen temperate and subpolar broad-leaved rain forest
I.A.6. Closed canopy evergreen temperate seasonal broad-leaved
I.A.7. Closed canopy winter-rain, broad-leaved sclerophyllous canopy
I.C.2. Closed canopy mixed evergreen-deciduous cold deciduous broad-leaved
II.A.1. Open canopy evergreen broad-leaved
II.C.2. Open canopy mixed evergreen-deciduous cold deciduous broad-leaved

CORINE LAND COVER
3.1.1 Broad-leaved Forest

3.1.2 Coniferous Forest

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
I.A.2b(2) Tropical/subtropical needle-leaved evergreen seasonal submontane forest

US FGDC VEGETATION CLASSIFICATION STANDARDS
I.A.8. Closed canopy evergreen tropical and subtropical needle-leaved
I.A.9. Closed canopy evergreen temperate and subpolar needle-leaved
I.C.3 Closed canopy mixed evergreen-deciduous cold deciduous needle-leaved
II.A.2. Open canopy evergreen needle-leaved
II.C.3 Open canopy mixed evergreen-deciduous needle-leaved
II.C.4 Open canopy mixed evergreen-deciduous cold deciduous needle-leaved

CORINE LAND COVER
3.1.2 Coniferous Forest

3.1.3 Mixed Forest

CORINE LAND COVER
3.1.3 Mixed Forest

CORINE LAND COVER
3.2 Shrub and/or Herbaceous Vegetation Associations

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
IV.D Tundra
IV.E Mossy Bog Formations with Dwarf-Shrub
V.A Tall Graminoid Vegetation
V.B. Medium Tall Grassland
V.C. Short Grassland
V.D Forb Vegetation

US FGDC VEGETATION CLASSIFICATION STANDARDS
Shrub Dominated
Herb Dominated

VEGETATION MAP OF PAPUA NEW GUINEA
Grassland
Mixed Herbaceous Vegetation

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Grasslands

CORINE LAND COVER
1.4.2 Sport & Leisure Facilities
3.2 Shrub and/or Herbaceous Vegetation Associations

ANDERSON *ET AL.* (1976)
3.1 Herbaceous Rangeland
6.2 Nonforested Wetland

CAMBODIA LAND COVER ATLAS
19 Abandoned Shrublands
21 Grasslands
22 Grass Savannah
24 Abandoned Grasslands

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
140 Agricultural Land - Grass Crops

3.2.1 Natural Grassland

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
IV.D Tundra
IV.E Mossy Bog Formations with Dwarf-Shrub
V.A Tall Graminoid Vegetation
V.B. Medium Tall Grassland
V.C.7 Short to Medium Tall Mesophytic Grassland
V.D Forb Vegetation

US FGDC VEGETATION CLASSIFICATION STANDARDS
Herb Dominated

VEGETATION MAP OF PAPUA NEW GUINEA
Grassland
Mixed Herbaceous Vegetation

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Grasslands

CORINE LAND COVER
1.4.2 Sport & Leisure Facilities
3.2.1 Natural Grassland

ANDERSON *ET AL.* (1976)
3.1 Herbaceous Rangeland
6.2 Non-forested Wetland

CAMBODIA LAND COVER ATLAS
21 Grasslands
22 Grass Savannah
24 Abandoned Grasslands

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
140 Agricultural Land - Grass Crops

CORINE LAND COVER

3.2.2 Moors & Heathland	**UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION** V.D Forb Vegetation **US FGDC VEGETATION CLASSIFICATION STANDARDS** Shrub Dominated Herb Dominated **VEGETATION MAP OF PAPUA NEW GUINEA** Mixed Herbaceous Vegetation **CORINE LAND COVER** 3.2.2 Moors & Heathland **CAMBODIA LAND COVER ATLAS** 19 Abandoned Shrublands
3.2.3 Sclerophyllous Vegetation	**UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION** I.A.5 Mangrove Forest I.A.8 Winter-rain Evergreen Broad-leaved Sclerophyllous Forest II.A.1 Evergreen Broad-leaved Woodland II.C.1 Sclerophyllous-dominated extremely xeromorphic woodland **CORINE LAND COVER** 3.2.3 Sclerophyllous Vegetation
3.2.4 Transitional Woodland / Scrub	**CORINE LAND COVER** 3.2.4 Transitional Woodland / Scrub **CAMBODIA LAND COVER ATLAS** 22 Grass Savannah
3.3 Open Spaces with little or no Vegetation	**IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Snow and Ice Barren **CORINE LAND COVER** 3.3 Open Spaces with little or no Vegetation **ANDERSON *ET AL.* (1976)** 7.2 Beaches 7.3 Sandy Areas other than Beaches 7.4 Bare Exposed Rock **CAMBODIA LAND COVER ATLAS** 25 Marches **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 198 Rocks 210 Perennial Snow or Ice
3.3.1 Beaches, Dunes & Sand Plains	**CORINE LAND COVER** 3.3.1 Beaches, Dunes & Sand Plains **ANDERSON *ET AL.* (1976)** 7.2 Beaches 7.3 Sandy Areas other than Beaches

CORINE LAND COVER **3.3.2 Bare Rocks**	**IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Barren **CORINE LAND COVER** 3.3.2 Bare Rocks 3.3.3 Sparsely Vegetated Areas **ANDERSON *ET AL.* (1976)** 7.4 Bare Exposed Rock **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 198 Rocks
3.3.3 Sparsely Vegetated Areas	**CORINE LAND COVER** 3.3.3 Sparsely Vegetated Areas
3.3.4 Burnt Areas	**CORINE LAND COVER** 3.3.4 Burnt Areas
3.3.5 Glaciers & Permanent Snow	**IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Snow and Ice **CORINE LAND COVER** 3.3.5 Glaciers & Permanent Snow **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 210 Perennial Snow or Ice

CORINE LAND COVER
4 Wetlands

RANGE & FOREST RESOURCES OF SENEGAL

Herbaceous Steppes
Urban and quarries

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION

I.A.2a Tropical/Subtropical Evergreen Seasonal Lowland Forest
I.A.2c Tropical/Subtropical Evergreen Seasonal Montane Forest
I.A.2d Tropical/Subtropical Evergreen Dry Sub-alpine Forest
I.A.6 Temperate/Sub-polar Evergreen Ombrophilous Forest
I.A.7 Temperate Evergreen Seasonal Broad-leaved Forest
I.B.3 Cold-deciduous Forest without Evergreen Trees
I.C.1 Sclerophyllous-dominated Extremely Xeromorphic Forest
II.C.1 Sclerophyllous-dominated Extremely Xeromorphic Woodland
IV.A.3 Mixed Evergreen Dwarf-shrub and Herbaceous Formations
IV.C Extremely Xeromorphic Dwarf-Shrubland
IV.D Tundra
V.A.3 Tall Grassland & Synusia of Shrubs
V.A.4 Tall Grassland & Woody Synusia of Tuft Plants
V.B.3 Medium Tall Grassland (3)
V.C.3 Short Grassland (3)
V.C.4 Short Grassland (4)
V.E Hydromorphic Fresh-Water Vegetation (Aquatic)

US FGDC VEGETATION CLASSIFICATION STANDARDS

F. Hydromorphic Rooted Vegetation
VI.A.1 Herbaceous Non-Vascular Dominated Bryoid Vegetation with Tree Layer
VI.A.2 Herbaceous Non-Vascular Dominated Bryoid Vegetation with Shrub Layer
VI.B.1 Herbaceous Non-Vascular Dominated Lichen Vegetation with Tree Layer
VI.B.2 Herbaceous Non-Vascular Dominated Lichen Vegetation with Shrub Layer
VI.B.3 Herbaceous Non-Vascular Dominated Lichen Vegetation with Dwarf Shrub Layer

VEGETATION MAP OF PAPUA NEW GUINEA

Montane forest
Savanna
Grassland

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'

Woody Savannas
Savannas
Permanent Wetlands
Developed Lands

CORINE LAND COVER

1.2.3 Port Areas
1.2.4 Airports
1.3 Mine, Dump and Construction Sites
1.4.1 Green Urban Areas
2.1.3 Rice Fields
2.3 Pastures
2.4.2 Complex Cultivation Patterns
2.4.4 Agro-forestry Areas
3.2.4 Transitional Woodland/Scrub
3.3.2 Bare Rocks
4 Wetlands
5.1.2 Water Bodies
5.2 Marine Waters

ANDERSON *ET AL.* (1976)

2.1 Cropland & Pastures
3.3 Mixed Rangeland
5.2 Lakes
5.3 Reservoirs
5.4 Bays & Estuaries
7.1 Dry Salt Flats
8.2 Herbaceous Tundra
8.4 Wet Tundra

CAMBODIA LAND COVER ATLAS

2 Paddy Fields
3 Receding & Floating Rice Fields
14 Flooded Forest
16 Mangrove Forest
23 Flooded Grass

CORINE LAND COVER
4 Wetlands

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
170 Wetland
220 Water

4.1 Inland Wetlands

RANGE & FOREST RESOURCES OF SENEGAL
Herbaceous Steppes

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
I.A.2a Tropical/subtropical evergreen seasonal lowland Forest
I.A.2c Tropical/subtropical evergreen seasonal montane Forest
I.A.2d Tropical/subtropical evergreen dry sub-alpine Forest
I.A.6 Temperate & Sub-polar Evergreen Ombrophilous Forest
I.A.7 Temperate Evergreen Seasonal Broad-leaved Forest
I.B.3 Cold-deciduous Forest without Evergreen Trees
I.C.1 Sclerophyllous-dominated extremely Xeromorphic Forest
II.C.1 Sclerophyllous-dominated extremely Xeromorphic Woodland
IV.A.3 Mixed Evergreen Dwarf-shrub and Herbaceous Formations
IV.C Extremely Xeromorphic Dwarf-Shrubland
IV.D Tundra
IV.E Mossy Bog Formations with Dwarf-Shrub
V.A.3 Tall Grassland & Synusia of Shrubs
V.A.4 Tall Grassland & Woody Synusia of Tuft Plants
V.B.3 Medium Tall Grassland (3)
V.C.3 Short Grassland (3)
V.C.4 Short Grassland (4)
V.E Hydromorphic Fresh-Water Vegetation (aquatic)

US FGDC VEGETATION CLASSIFICATION STANDARDS
V.F Hydromorphic rooted vegetation
VI.A.1 Non-Vascular Dominated: Bryoid Vegetation with Tree Layer
VI.A.2 Non-Vascular Dominated: Bryoid Vegetation with Shrub Layer
VI.B.1 Non-Vascular Dominated: Lichen Vegetation with Tree Layer
VI.B.2 Non-Vascular Dominated: Lichen Vegetation with Shrub Layer
VI.B.3 Non-Vascular Dominated: Lichen Vegetation with Dwarf Shrub Layer

VEGETATION MAP OF PAPUA NEW GUINEA
Montane forest
Savanna
Grassland

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Woody Savannas
Savannas
Permanent Wetlands
Developed Lands

CORINE LAND COVER
1.2.3 Port Areas
1.2.4 Airports
1.4.1 Green Urban Areas
2.1.3 Rice Fields
2.3 Pastures
2.4.2 Complex Cultivation Patterns
2.4.4 Agro-forestry Areas
3.2.4 Transitional Woodland/Scrub
4.1 Inland Wetlands
5.1.2 Water Bodies
5.2 Marine Waters

ANDERSON *ET AL.* (1976)
2.1 Cropland & Pastures
2.3 Confined Feeding Operations
5.2 Lakes
5.3 Reservoirs
5.4 Bays & Estuaries
8.2 Herbaceous Tundra
8.3 Wet Tundra

CORINE LAND COVER
4.1 Inland Wetlands

CAMBODIA LAND COVER ATLAS
2 Paddy Fields
3 Receding & Floating Rice Fields
14 Flooded Forest
16 Mangrove Forest
23 Flooded Grass

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
170 Wetland
222 Inland Water

4.1.1 Inland Marshes

CORINE LAND COVER
4.1.1 Inland Marshes

CAMBODIA LAND COVER ATLAS
14 Flooded Forest
15 Secondary Flooded Forest
23 Flooded Grass

LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING
224 Water with Seasonal Change

4.1.2 Peat Bogs

RANGE & FOREST RESOURCES OF SENEGAL
Herbaceous Steppes

UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION
I.A.2a Tropical/subtropical evergreen seasonal lowland forest
I.A.2c Tropical/subtropical evergreen seasonal montane forest
I.A 2d Tropical/subtropical evergreen dry sub-alpine forest
I.A.6 Temperate/Sub-polar Evergreen Ombrophilous Forest
I.A.7 Temperate Evergreen Seasonal Broad-leaved Forest
I.B.3 Cold-deciduous forest without evergreen trees
I.C.1 Sclerophyllous-dominated extremely xeromorphic forest
II.C.1 Sclerophyllous-dominated extremely xeromorphic woodland
IV.A.3 Mixed Evergreen Dwarf-shrub and herbaceous formations
IV.C Extremely Xeromorphic Dwarf-Shrubland
IV.D Tundra
IV.E Mossy Bog Formations with Dwarf-Shrub
V.A.3 Tall Grassland & Synusia of Shrubs
V.A.4 Tall Grasland & Woody Synusia of Tuft Plants
V.B.3 Medium Tall Grassland (3)
V.C.3 Short Grassland (3)
V.C.4 Short Grassland (4)

US FGDC VEGETATION CLASSIFICATION STANDARDS
F Hydromorphic rooted vegetation
VI.A. 1. Non-vascular Dominated Bryoid Vegetation with Tree Layer
VI.A. 2. Non-vascular Dominated Bryoid Vegetation with Shrub Layer
VI.B.1. Non-vascular Dominated Lichen Vegetation with Tree Layer
VI.B.2. Non-vascular Dominated Lichen Vegetation with Shrub Layer
VI.B.3. Non-vascular Dominated Lichen Vegetation with Dwarf Shrub Layer

VEGETATION MAP OF PAPUA NEW GUINEA
Montane forest
Dry evergreen forest
Woodland
Scrub
Savanna
Grassland

IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'
Woody Savannas
Savannas
Permanent Wetlands
Developed Lands

CORINE LAND COVER **4.1.2 Peat Bogs**	**CORINE LAND COVER** 1.2.4 Airports 1.4.1 Green Urban Areas 2.3 Pastures 2.4.2 Complex Cultivation Patterns 2.4.4 Agro-forestry Areas 3.2.4 Transitional Woodland/Scrub 4.1.2 Peat Bogs **ANDERSON *ET AL.* (1976)** 2.1 Cropland & Pastures 3.3 Mixed Rangeland 8.2 Herbaceous Tundra 8.4 Wet Tundra **CAMBODIA LAND COVER ATLAS** 23 Flooded Grass
4.2 Maritime Wetlands	**CORINE LAND COVER** 4.2 Maritime Wetlands
4.2.1 Salt Marshes	**CORINE LAND COVER** 4.2.1 Salt Marshes
4.2.2 Salines	**CORINE LAND COVER** 4.2.2 Salines **ANDERSON *ET AL.* (1976)** 7.1 Dry Salt Flats
4.2.3 Inter-Tidal Flats	**CORINE LAND COVER** 4.2.3 Inter-Tidal Flats
5 Water Bodies	**UNESCO - INTERNATIONAL CLASSIFICATION & MAPPING OF VEGETATION** V.E Hydromorphic Fresh-Water Vegetation (Aquatic) **US FGDC VEGETATION CLASSIFICATION STANDARDS** F. Hydromorphic rooted vegetation **IGBP-DIS GLOBAL 1KM LAND COVER DATA SET 'DISCOVER'** Permanent Wetlands **CORINE LAND COVER** 1.2.3 Port Areas 2.1.3 Rice Fields 4.1 Inland Wetlands 5 Water Bodies **ANDERSON *ET AL.* (1976)** 5.2 Lakes 5.3 Reservoirs 5.4 Bays & Estuaries 8.4 Wet Tundra **CAMBODIA LAND COVER ATLAS** 2 Paddy Fields 3 Receding & Floating Rice Fields 14 Flooded Forest 16 Mangrove Forest 23 Flooded Grass **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 170 Wetland 222 Inland Water

CORINE LAND COVER **5.1 Inland Wetlands**	**CORINE LAND COVER** 2.1.3 Rice Fields 5.1 Inland Waters 5.2.2 Estuaries **ANDERSON *ET AL.* (1976)** 8.4 Wet Tundra **CAMBODIA LAND COVER ATLAS** 2 Paddy Fields 3 Receding & Floating Rice Fields 14 Flooded Forest 23 Flooded Grass
5.1.1 Water Courses	**CORINE LAND COVER** 5.1.1 Water Courses 5.2.2 Estuaries
5.1.2 Water Bodies	**CORINE LAND COVER** 2.1.3 Rice Fields 5.1.2 Water Bodies **ANDERSON *ET AL.* (1976)** 8.4 Wet Tundra **CAMBODIA LAND COVER ATLAS** 2 Paddy Fields 3 Receding & Floating Rice Fields 14 Flooded Forest 23 Flooded Grass
5.2 Marine Waters	**CORINE LAND COVER** 4 Wetlands 5.2 Marine Waters **ANDERSON *ET AL.* (1976)** 5.4 Bays & Estuaries **CAMBODIA LAND COVER ATLAS** 16 Mangrove Forest **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 172 Mangrove
5.2.1 Coastal Lagoons	**CORINE LAND COVER** 5.2.1 Coastal Lagoons
5.2.2 Estuaries	**CORINE LAND COVER** 5.2.2 Estuaries
5.2.3 Sea & Ocean	**CORINE LAND COVER** 4 Wetlands 5.2.2 Estuaries 5.2.3 Sea & Ocean **ANDERSON *ET AL.* (1976)** 5.4 Bays & Estuaries **CAMBODIA LAND COVER ATLAS** 16 Mangrove Forest **LAND COVER WORKING GROUP OF THE ASIAN ASSOCIATION ON REMOTE SENSING** 172 Mangrove